POWER

Volume 53 New York, May 3, 1921 *Number* 18

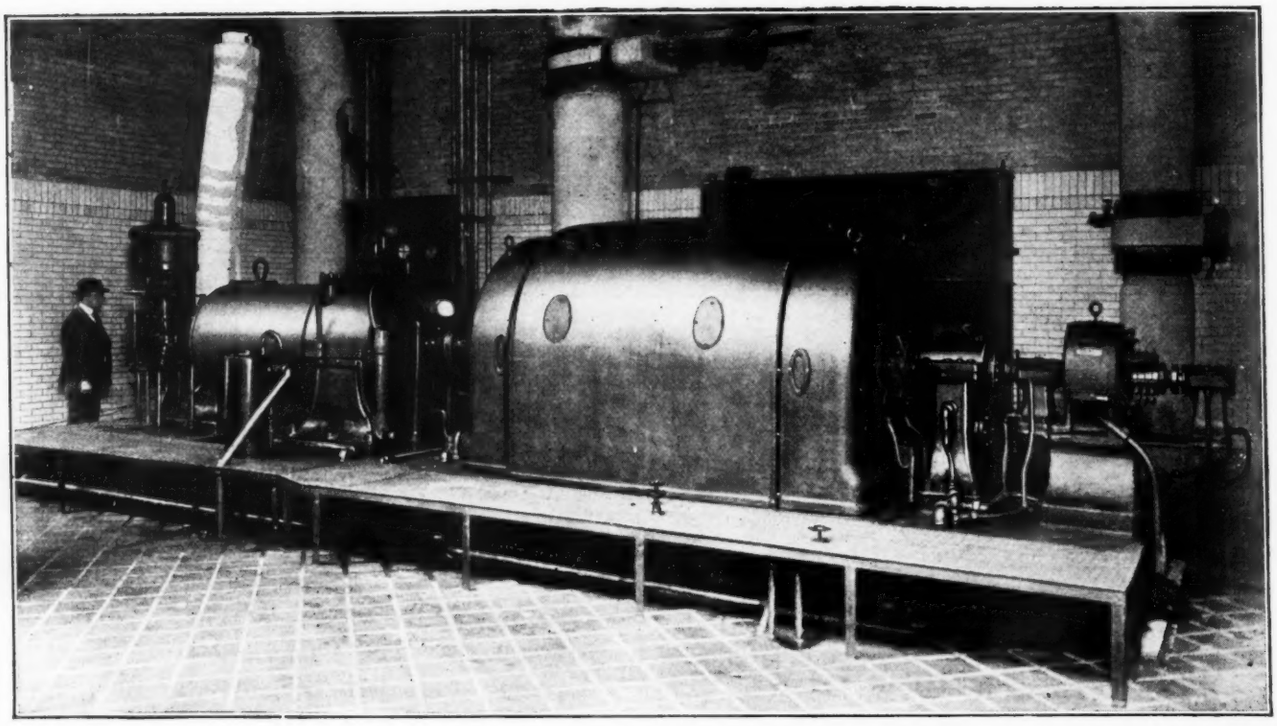
If Rents, Why Not Coal Also?

THE Supreme Court of the United States has ruled that Congress or any state legislative body has a right in time of emergency to regulate rentals or property so that the gouging landlord may not take undue advantage or accomplish unjust eviction of tenants. This in effect is the meaning of the decision announced by the Court on April 18. It at once suggests the question: If rentals can be regulated thus, is it not altogether proper that coal, an equivalent necessity, should also be subject to governmental scrutiny and supervision?

The Federal Trade Commission has been attacked frequently for undertaking to gather coal figures, on the ground that demanding information of this type invades the private rights of corporations or individuals and is, therefore, "unconstitutional." It would seem that the Supreme Court has convincingly repudiated such a claim and established clearly the right of Congress to enact legislation making possible the gathering and making available information for the protection of the public as to the ownership, production, distribution, costs, sales and profits in the coal industry. If so, the coal users of America (and who are not coal users?) may hold hope.

Any business man can join heartily with President Harding in his desire that there shall be a minimum of Government in business and a maximum of business in Government. But at the same time business men are not prone to look with suspicion upon the Government when it demands that the basic necessities of industrial and domestic life be fairly managed by business and that the rights of the individual and the corporations be reasonably secure against attack by any industry or corporate influence within industry which may be willing to overcharge the public in time of emergency. In this there should be almost unanimous agreement.

When one comes to suggest the means by which to accomplish and apply the general principle, there is wide diversity of opinion. However, it appears that the vast majority of thinking people would have the Government secure adequate information with respect to the coal business so that the public and the coal purchaser individually can know whether the price which he is being asked is or is not approximately fair and reasonable. It is to be hoped that this finding of our highest judicial tribunal will greatly hearten those who stand for the general principles of the legislation proposed by Mr. Calder and recommended to the recent session of Congress by the La Follette committee. May its enactment be assured at an early date and its enforcement be most promptly undertaken.



2,000-KW. TURBO-GENERATOR ON HEAT-BALANCE SYSTEM

Boilers and Auxiliary Equipment Colfax Power Station

MUCH has been said regarding the location of large power stations at the mouths of coal mines. If such a location is to be successful there must be near the mine an abundant water supply for condensing purposes. Sites where large quantities of coal and water are in proximity are comparatively few. Not only is the Colfax station of the Duquesne Light Co. located at one of these sites, but it is also within the great industrial district of Pittsburgh, where there are large demands for power. As pointed out in the issue of April 5, this station will ultimately have installed in it six 60,000-kw. units, each consisting of a three-cylinder cross-compound type turbine, driving three 20,000-kw., 12,000-volt alternators, operating in multiple as a single unit. Since the Allegheny River at minimum flow can supply condensing water for only 300,000 kw., the capacity of the station will be limited to this figure, the sixth unit being used as a spare.

SEVEN boilers installed, each of 20,876 square feet of heating surface, fired under the low end. Furnace volume 0.345 cubic feet per square foot of heating surface. House turbine exhausts into barometric condenser, which acts as the feed-water heater. Heat balance system of particular interest.

Coal for the Colfax station is obtained from the company's mine about one mile from the plant. This coal is semi-bituminous, having a heat value of about 13,500 B.t.u. as received from the mine, and has a proximate analysis of 54 per cent fixed carbon, 34 per cent volatile matter, 9 per cent ash and 3 per cent moisture. Great care has been taken to facilitate the movement of the coal from the mine to the boiler furnace with a minimum number of handlings.

At one end of the boiler house there are two large track hoppers, 18 x 34 ft., each holding 150 tons, into which may be dumped the coal from railway cars direct from the mine. From each of these hoppers an apron feeder serves a double-roll crusher. These duplicate crushers are placed so that they are readily accessible, and I-beam rails are provided on which they can easily be shifted out from their normal position to a point where ample room is available for repairs. From each crusher the coal is fed into Peck carriers of the overlapping, pivoted-bucket type, running at a speed of 60 ft. per min. and delivering the coal to two 30-in. belt conveyors, running over the bunker and equipped with automatic traveling trippers, Fig. 7. A continuous sample is taken of all coal as it goes to the belts. Grinding mills are provided which extract 10 per cent of this sample, which is quartered for testing. The entire coal-handling apparatus is in duplicate throughout, each half of the system having a capacity of 200 tons per hour.

The boilers are arranged in two rows facing a central firing aisle, running parallel with the turbine room. Over the firing aisle is the reinforced-concrete coal bunker, which has a capacity of 10 tons per lineal foot, or 240 tons per boiler. Two 20-ton weighing larries with recording registers take the coal from the bunker and deliver it to the extension hoppers over the stokers. All coal-handling apparatus is electrically driven.

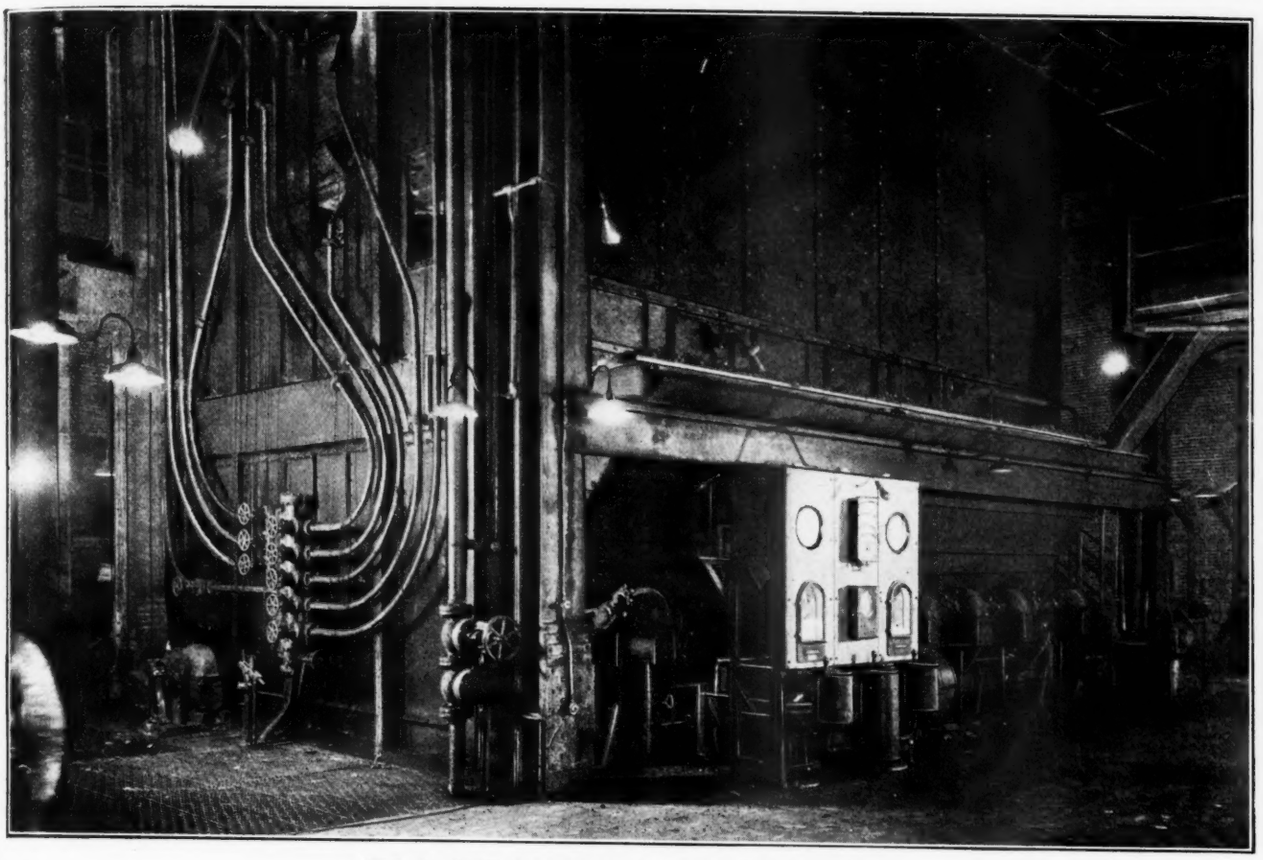


FIG. 1. SIDE AND FRONT VIEW OF ONE BOILER

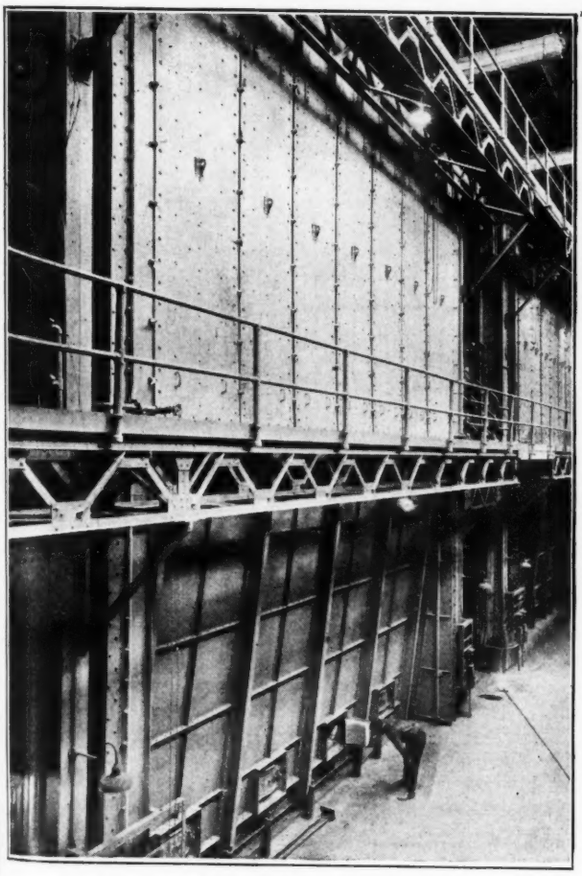


FIG. 2. BACK VIEW OF BOILERS

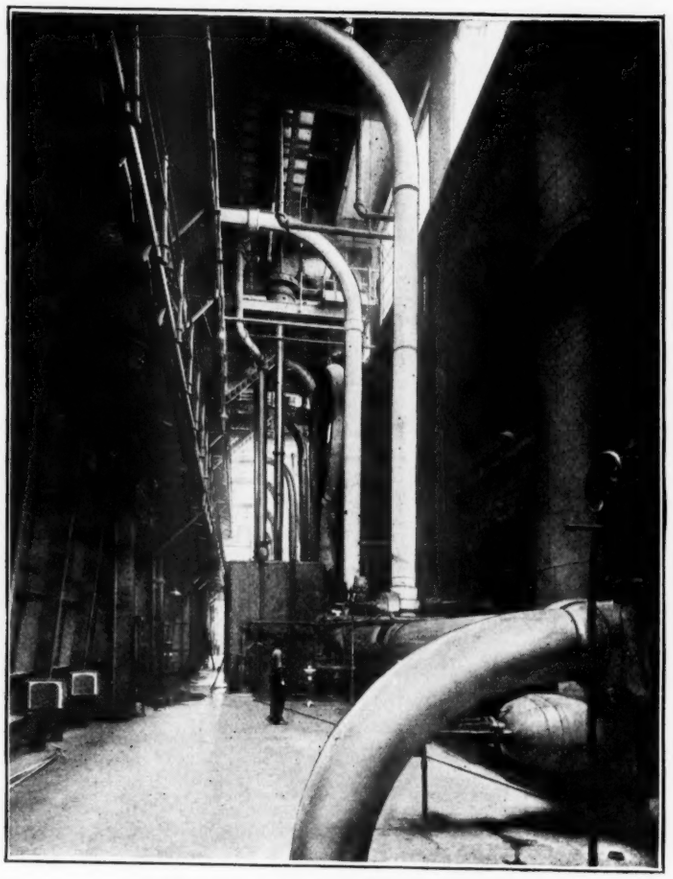


FIG. 3. PIPING BACK OF BOILERS

The stokers are equipped with double-roll clinker grinders (see Fig. 4) protected by continuous water sprays. These grinders discharge the ashes into large, reinforced-concrete brick-lined hoppers which have a capacity of 1,900 cu.ft. per boiler. Air-operated ash gates permit the loading of standard railway cars on

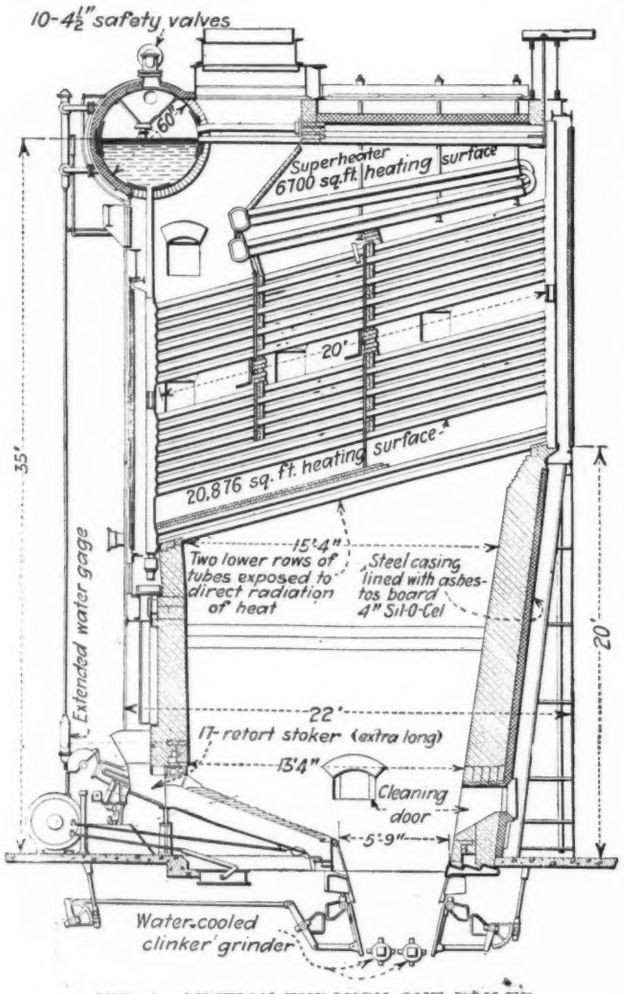


FIG. 4. SECTION THROUGH ONE BOILER

tracks directly below the ashpit. Liberal provision has been made for wetting down the ashes and for thoroughly draining the floors underneath these ashpits.

In order to secure the greatest reliability, with due regard for economy, it has been a settled policy not to use in this station any materials or methods which have not been time-proved. Metals now used in piping and in steam-driven apparatus are well known to be reliable at a total steam temperature of about 600 deg. F. With this limit adopted, there was a choice between using a boiler pressure of 275 lb. and approximately 200 deg. superheat, or using boilers designed for a higher pressure and less superheat. However, it was decided to adopt the lower boiler pressure.

Babcock & Wilcox boilers (Figs. 1 to 4) of the widest practicable width were selected, being 51 tubes wide and limited to this by the maker's inability to manufacture longer cross-drums without circumferential seams. Similarly, the boilers are 18 tubes high, the highest developed to the date of their construction, giving a maximum amount of heating surface per foot of furnace width. The tubes are 20 ft. long, each boiler containing 20,876 sq.ft. of heating surface and covering a floor space about 34 ft. wide and 22 ft. from front to back.

Fig. 4 shows a cross-section through one of the boilers, and it will be seen that they are turned around from the usual method of setting this type. The tubes incline down toward what is now the front, thus bringing the blowoff at the front instead of at the rear. The boilers are set exceptionally high. The distance from the floor to the bottom of the uptake header, which is the dimension normally used in comparing such settings, is 20 ft., while the center line of the drum is 35 ft. above the floor. This setting gives a furnace volume of approximately 0.345 cu.ft. per square foot of heating surface and is thought to be the most liberal furnace volume designed to the date of this installation.

The heating surface is arranged with the so-called drop-tube construction, in which the two lower tubes are dropped below the tube bank above and are exposed to the direct radiant heat of the furnace, which, with the boilers being fired under the downtake end, constitutes what is known as the "Alert" furnace and is designed to permit high furnace temperatures with a minimum of brickwork upkeep. The arrangement of baffling employed is shown in the figure, and it will be noticed that the boilers are fired at one end only. This station, at least for many years to come, will carry the base load of the system and will have a relatively high load factor. A careful study of the all-year performance indicates that the lowest yearly cost so far as boiler plant is concerned will, for the first few units of the

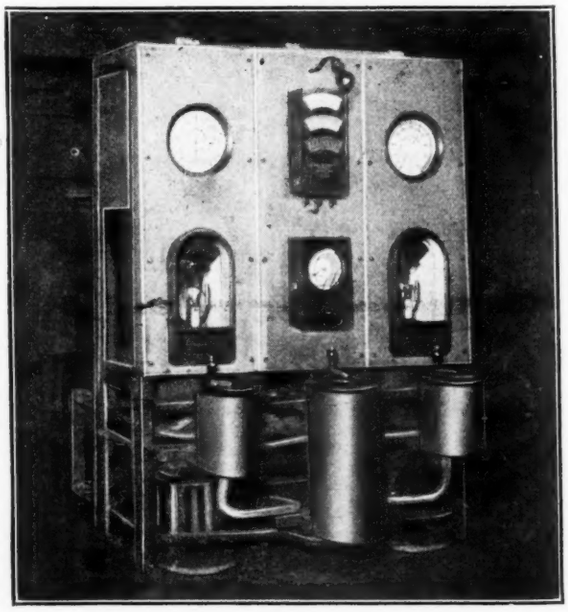


FIG. 5. BOILER INSTRUMENT BOARD

station, be found in running the boilers at between 200 and 225 per cent normal rating when the main unit is carrying its full rated load. At the same time the width of the boilers permitted using stokers of 17 retorts, and as these are of the extra-long type they will burn enough coal to run the boilers at 300 per cent of rating for short periods. Hence the same boiler capacity which will most economically serve the main units at full rated load will also furnish enough steam to develop the full overload capacity of these units. This overload capac-

ity, available only in the winter months, at which time the system peak loads occur, amounts to an additional 10,000 kw. over the normal rating of 60,000 kw.

All boilers are steel-incased, and in general the furnace lining consists of 4 in. of Sil-O-Cel, ¼ in. asbestos millboard and 18 in. of firebrick next to the fire. In all

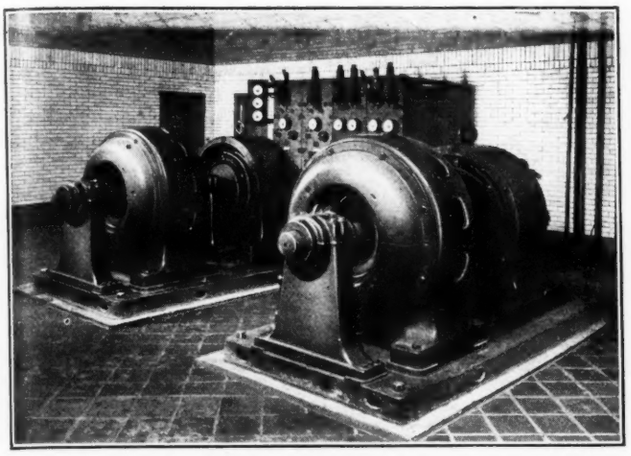


FIG. 6. MOTOR-GENERATOR SETS FOR SUPPLYING DIRECT CURRENT TO STOKER AND CLINKER-GRINDER MOTORS

the furnace walls at the level of the coal bed there are perforated blocks through which a small amount of air is admitted to prevent the formation of clinker on the walls. Attention is called to the construction of the rear wall, which, being inclined, insures stability and avoids many of the vexatious difficulties heretofore met with in bridge-wall construction. Fig. 1 shows a front view of the completed boiler, on which will be noticed the arrangement of the soot-blower piping and its controlling valves, as well as the location of the boiler-gage board.

Each boiler is equipped with a superheater of the Foster type, located above the tubes, between the first and second pass (see Fig. 4), containing 6,700 sq.ft. of surface and giving from 140 deg. F. of superheat at the lower boiler ratings to about 200 deg. F. when the boilers are operated at 250 per cent rating or higher.

Ten 4½-in. safety valves, set at 285 lb. gage, are located on each 60-in. steam drum. Two 8-in. connections are made between the drum and superheater, which is divided into two parts. On each superheater outlet, which is also 8 in. in diameter, is a 3½-in. safety valv

The boilers are equipped with feed-water regulators, water-flow meters, draft gages, pyrometers, CO_2 recorders and with extended water columns, so that the water level is plainly indicated at the firing-floor level. In front of each boiler is a gage board, Fig. 5, on which are mounted two indicating steam-pressure gages, two indicating and recording feed-water meters, one three-scale indicating draft gage, one CO_2 recorder. Directly beneath this gage board are the controllers for the stoker and clinker-grinder motors; these motors are of the variable-speed direct-current type, supplied with power from a 200-kw., 250-volt direct-current generator driven by a 325-hp., 2,300-volt induction motor, Fig. 6.

Natural draft for carrying away the gases of combustion is furnished by self-supporting steel stacks carried on the framework of the boiler room. They are brick-lined throughout, and each stack serves four boilers. Each stack has a minimum internal diameter of 21 ft., and they extend 325 ft. above the grates, thus insuring the draft necessary in conjunction with the forced draft on the stokers to permit running the boilers in winter months at 300 per cent of rating. The flues are of sheet metal and are carried above the roof, not only to minimize building costs but at the same time to avoid the excessively hot temperatures often found in the upper portions of a boiler plant. They are covered with 2 in. of 85 per cent magnesia and are protected with a sheet-metal covering.

Each group of four boilers is served by one forced-draft fan, with a maximum capacity of 250,000 cu.ft. of air per minute at 65 deg. F. against a static pressure of 6 in. of water. The fans take their supply of air from the generator-cooling air and from the boiler-room basement. The housings are so arranged that the 420-hp. geared turbines driving these fans are located in the auxiliary bay between boiler and turbine rooms, Fig. 8, thus conforming to the plan of locating all rotating steam apparatus where it is under care of the turbine-room operators. The sheet-metal air ducts are so arranged that the different fans and boiler groups may be interconnected. The fan speed is automatically controlled upon a basis of boiler pressure, while the individual boiler outlet dampers are automatically controlled on a basis of draft intensity over the fire. Manually controlled dampers are in the air ducts to each boiler.

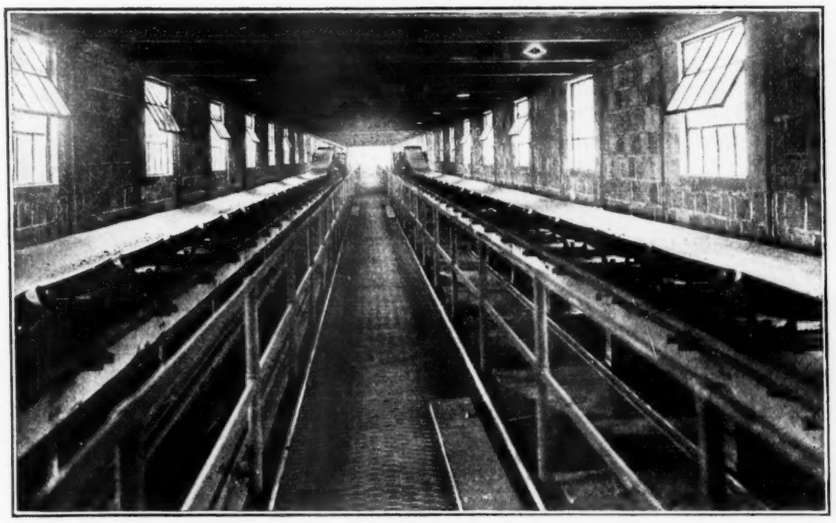


FIG. 7. COAL CONVEYORS OVER BUNKERS

In planning these draft arrangements, as in other parts of the station, simplicity and ease of operation has been the keynote. The boiler units are so large and the anticipated load so uniform that extreme use of automatic regulating and controlling devices is neither desirable nor warranted.

Diagrams of the main and auxiliary steam and boiler feed-water piping are shown in Figs. 10 and 11. By

using single straight headers for main and auxiliary steam piping a simple layout has been obtained. The main steam header is 20 in. in diameter, boiler leads are 10 in. in diameter and the connection from the header to each main unit is 18 in. in diameter. All these lines

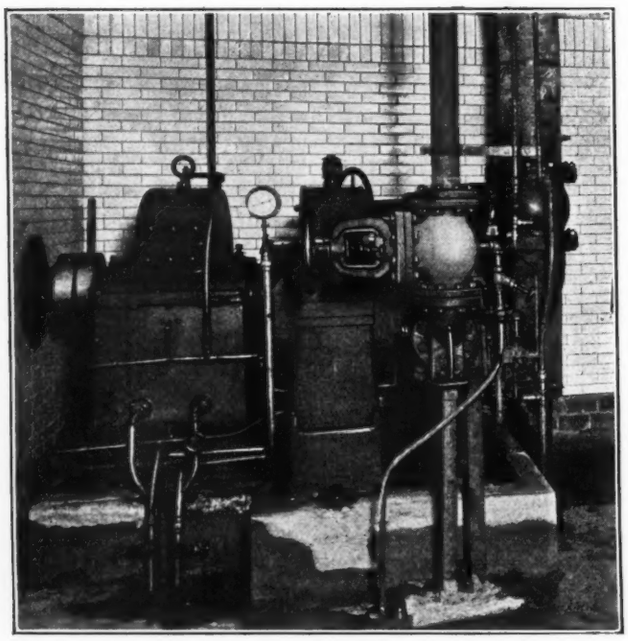


FIG. 8. FORCED-DRAFT FAN TURBINE

have motor-operated valves. The main steam header is located about four feet above the boiler-room floor, back of the boilers. Expansion and contraction are provided for by the use of expansion loops, one of which is shown in the center background, Fig. 3. In the flanged joints of the high-pressure steam piping double-threaded stud bolts of special, high-grade, oil-treated steel are used, it being felt that more reliable material could be obtained if the bolts were not upset for a head. This practice seems to have been fully justified by the fact that no trouble to date has been experienced with the bolted flanged joints in this high-pressure piping.

With the exception of boiler-feed pumps and forced-draft fans all auxiliaries are motor driven. The two exciters are of the duplex type and can be driven by either a motor or a turbine. However, since they are normally driven by motors they may be considered as motor driven so far as they affect station operation. Power for the electrically driven auxiliaries is furnished by a "house" or "service" turbo-generator of 2,000-kw. capacity (see headpiece). The house turbine exhausts into a barometric condenser which acts as the feed-water heater.

The makeup feed water required to replenish the system on account of soot blowers, drips, drains, blowing down the boilers and other leakage is supplied by a Lillie double-effect evaporator of the "dry-tube" type, Fig. 9, using exhaust steam from the boiler-feed pump and forced-draft turbines and having a capacity of 30,000 lb. per hour. The two effects are reversible, thus getting an automatic cracking or purging of the scale formed on the tubes. Recording meters of the venturi type are installed to measure both the raw water going to and the distillate coming from these evaporators. In addition to several smaller storage tanks used in the water systems, there will be for every two main units a 200,000-gal. main storage tank in the electrical bay basement for distilled water. One is installed at the present time. From the head tanks on the roof the water flows by gravity to the barometric condenser, where it is heated to 200 deg. F. by the house-turbine exhaust, and flows to the boiler feed-water tank, the latter acting as the seal on the tail pipe from the barometric condenser.

When furnished with 530,000 lb. of condensing water at an inlet temperature of 105 deg. F. the barometric condenser has a capacity of 50,000 lb. of steam an hour. The feed pumps are of the four-stage, centrifugal type, having a capacity of 1,500 gal. per min. and are direct-connected to 400-hp. non-condensing turbines taking steam at boiler pressure and temperature.

The method of using a house turbine to vary the amount of exhaust steam available for feed-water heating is not new nor is the use of a barometric condenser as a feed-water heater, but it is thought that the method provided for economically dividing the total auxiliary load between the house turbine and the main generators is new.

Variation in station load and consequently the quantity of main-unit condensate necessitate a practical method for regulation of house-turbine load and resultant exhaust steam in order to maintain the temperature of boiler-feed water at the proper point. To effect this change in house-turbine load by manually switching over auxiliaries from one supply to another is awkward and does not provide the desired degree of refinement in temperature adjustment. To parallel the house turbine directly with the main unit is impracticable because of the difference in characteristics making proper division of load difficult, and more especially because of the hazard introduced by exposing the auxiliary system to disturbances resulting from troubles outside the

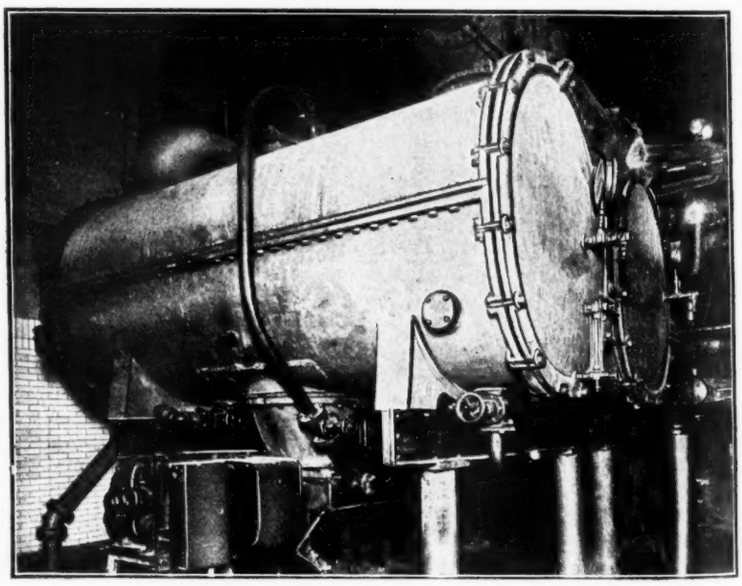
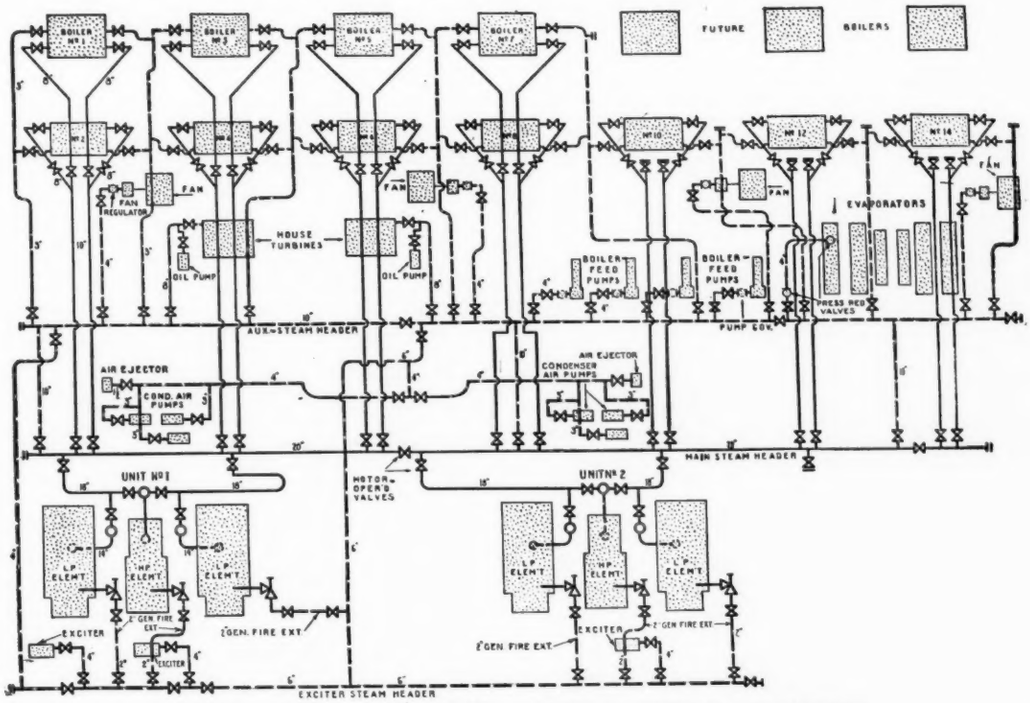
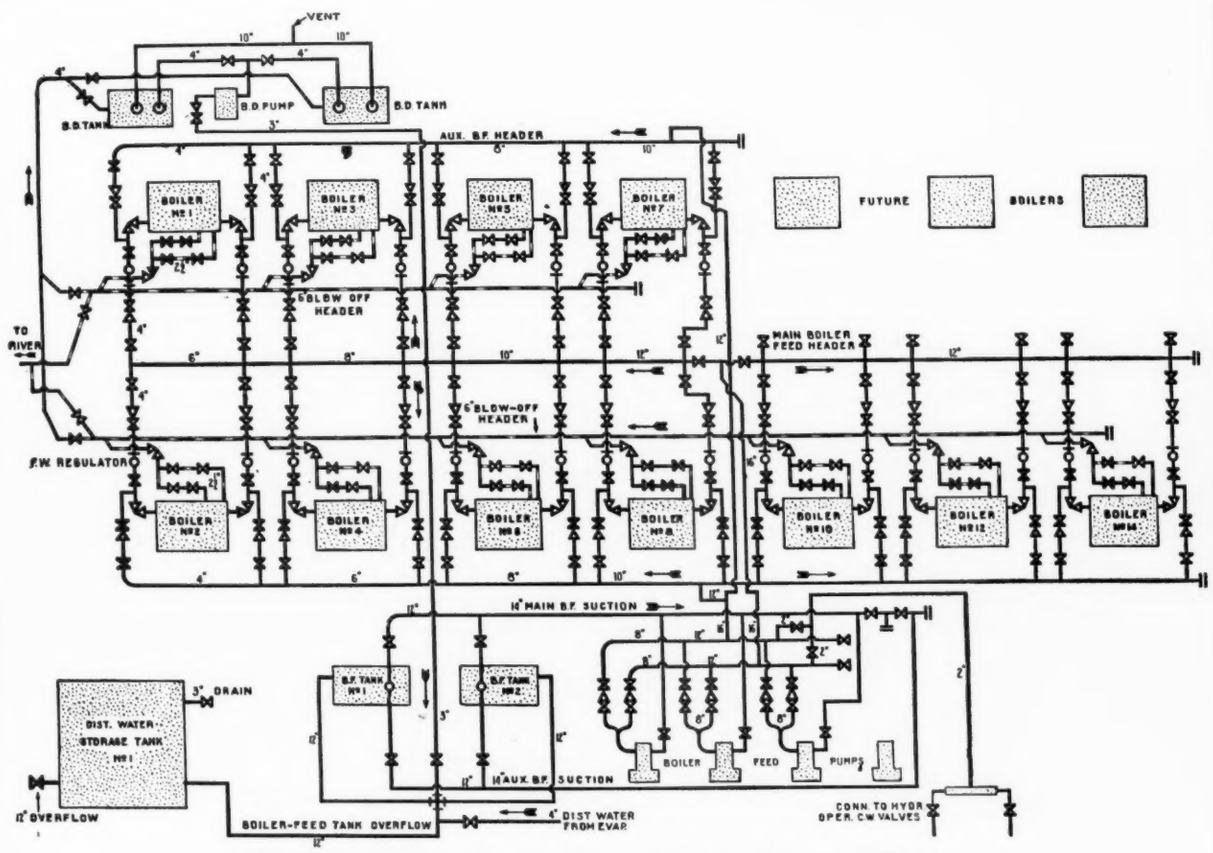


FIG. 9. MULTIPLE-EFFECT EVAPORATOR



MAIN AND AUXILIARY STEAM-PIPING DIAGRAM

FIG. 10



BOILER-FEED AND BLOW-OFF PIPING DIAGRAM

FIG. 11

station. Obviously a flexible coupling is necessary between the two sources of supply, which, while permitting the transfer of power under normal conditions, will not pass on to the auxiliary bus outside disturbances that might result in station shutdown. To perform the function of such a flexible tie between the two generating systems, an induction-motor generator set, Fig. 13, is in service at Colfax. The general scheme of connections is shown in Fig. 12.

An 1,100-hp. wound-rotor motor supplied from the main generator bus is directly connected to a 750-kw. synchronous generator which operates in parallel with the house turbine on the house-turbine bus. For a certain speed or cycle relation between the main-unit bus and the house-turbine bus this heat-balance motor-generator set will do no work, and the house turbine will generate enough energy to supply all the auxiliary circuits connected to its bus. If the speed of the house turbine is lowered without any change in the line-up of auxiliary circuits, the transfer set will carry load, and a part of the station auxiliary load will thus be served by the main generator through the medium of this set. As a result, with the same total load as before connected to the house-turbine bus, the house turbine itself now carries less load and there is consequently less exhaust steam available for heating the main-unit condensate for boiler feed.

In practice the load on the heat-balance set is controlled by changing the speed of the house turbine. Remote control of the house-turbine governor is provided in the switchboard room, where a graphic thermometer gives a continuous record of feed-water temperature.

The motor of the heat-balance set is of the wound-rotor type in order that variation in slip may be secured if required. The present control installation includes an external resistance left permanently connected in the secondary circuit. The ohmic resistance thus introduced gives a definite slip of 5 per cent in rotor speed when the synchronous generator is fully loaded. At such times the house turbine operates at 57 cycles, with a frequency of 60 cycles maintained in the supply to the heat-balance motor from the main bus.

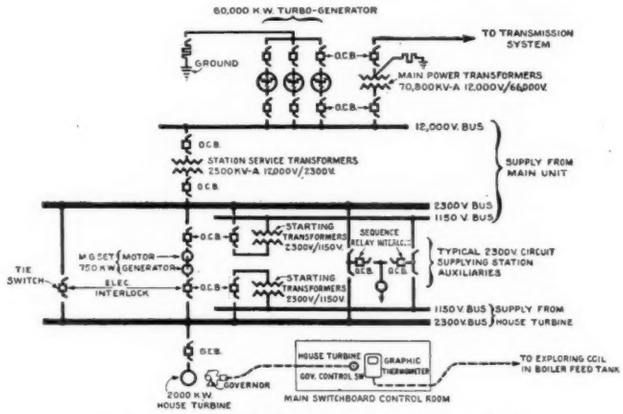


FIG. 12. AUXILIARY-CIRCUIT DIAGRAM

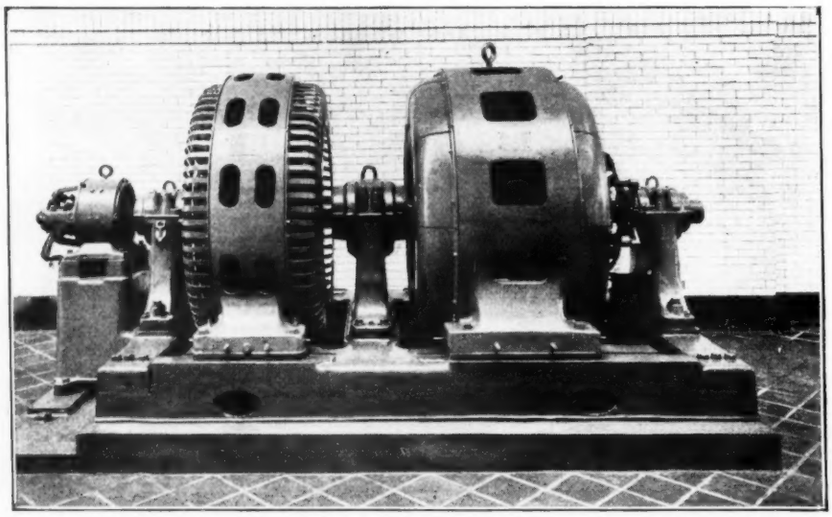


FIG. 13. MOTOR-GENERATOR SET ON HEAT-BALANCE SYSTEM

The heat-balance motor-generator set is equipped with reverse-power relays so that in case of any serious system trouble causing a drop in frequency to 54 cycles this set will trip out on reverse power, disconnecting the house-turbine system from the main generator bus and leaving the important auxiliaries supplied from the house turbine operating as a separate internal source of power unaffected by the outside disturbance. The only sacrifice will be the economy of heat balance during the period of the disturbance and until such time as the transfer set can again be synchronized with the house turbine and feed-water temperature adjusted. A more detailed story of the heat cycle will appear in May 24 issue of *Power*. As pointed out in the foregoing,

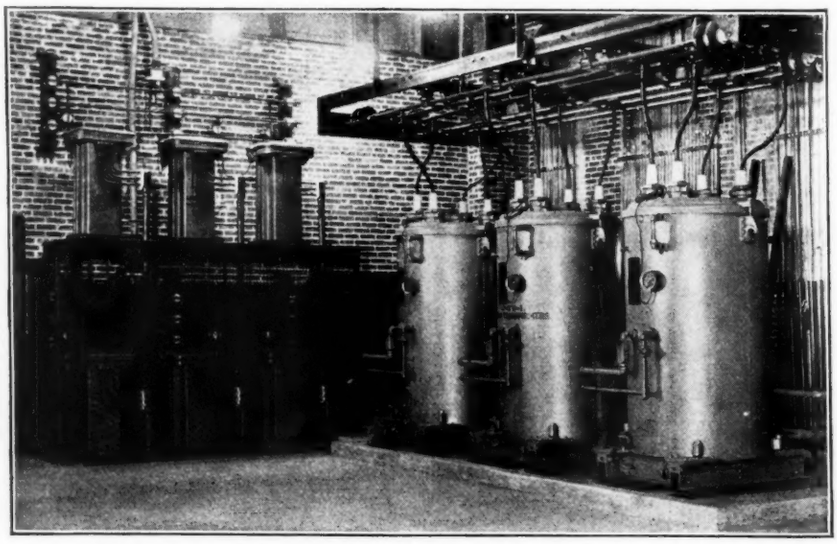


FIG. 14. TRANSFORMERS FOR STATION LIGHT AND POWER

with the exception of feed pumps and stoker fans all auxiliaries at Colfax are electrically driven. Motors above 75 hp. in rating are wound for 2,300 volts, smaller motors for 440 volts. A duplicate power supply for all motors is provided (a) indirectly from the main unit through a step-down station service-transformer bank, shown on the right, Fig. 14, and (b) directly from the 2,300-volt house turbo-generator.

All squirrel-cage 2,300-volt induction motors are started from a central 1,150-volt bus, Fig. 12. Switching is done by remote control, industrial push-button stations near the motors operating circuit breakers in bus-room compartments in the electrical bay. In the case of the larger auxiliary drives, where secondary-wound motors are required, as for example the 600-hp. units for the circulators, the starting connection is replaced by a drum-type controller with secondary resistance mounted near the motor. In several instances where desirable contactors operated by remote control are used instead of manually operated drum controllers.

In all cases 2,300-volt and 1,150-volt circuit breakers, compensators, instrument transformers and disconnecting switches are kept out of the turbine-room basement and other parts of the station where auxiliary motors are necessarily placed.

Thus the safety of the installation is increased and the liability of shutdown from accidental interference with live circuits reduced. Maximum simplicity in control is secured, and little knowledge or experience is required to start or stop satisfactorily the motors from the push-button stations.

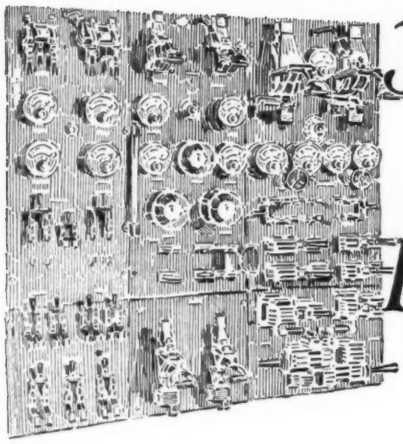
Power wishes to acknowledge the assistance and co-operation rendered in the preparation of this article by C. S. Cook, general manager, and J. M. Graves, assistant general manager of the Duquesne Light Co., and by various members of the organization of Dwight P. Robinson & Co., Inc., engineers and constructors of the Colfax power station.

TABLE OF PRINCIPAL EQUIPMENT IN COLFAX POWER PLANT

No.	Equipment	Capacity	Type	Manufacturer
1	Main turbo-generating unit	60,000 kw.	3-element cross-compound	Westinghouse Elec. & Mfg. Co.
7	Boilers	20,876 sq.ft. heating surface	Cross-drum, water-tube	Babcock & Wilcox Co.
7	Superheaters	6,700 sq.ft.	Foster	Power Specialty Co.
14	Clinker grinders		Double-roll	Westinghouse Elec. & Mfg. Co.
7	Stokers		17-Retort, extra-long	Westinghouse Elec. & Mfg. Co.
7	Soot blowers		18-units per boiler	Diamond Power Specialty Co.
3	Forced-draft fans	250,000 cu.ft. per min	Radial-flow	Green Fuel Economizer Co.
3	Forced-draft turbines	420 hp	Geared	Westinghouse Elec. & Mfg. Co.
3	Boiler-feed pumps	1,500 gal. per min	4-stage centrifugal	Worthington Pump & Mchy. Co.
3	Boiler-feed turbines	400 hp	Direct-connected	Westinghouse Elec. & Mfg. Co.
1	Evaporator	30,000 lb. per hr.	Lillie, double-effect	Wheeler Condenser & Engr. Co.
1	Feed-water heater		Barometric condenser	Westinghouse Elec. & Mfg. Co.
7	Boiler insulation		Sil-O-Cel	Celite Products Co.
	Furnace Cement		Hytempite	Quigley Furnace Specialties Co.
	Firebrick			Harbison & Walker
21	Coal gates		Duplex	C. W. Hunt Engineering Co.
	Smoke flues and forced draft ducts		Sheet metal	Connery & Co.
	Pipe and flue covering		85% magnesia	H. W. Johns-Manville Inc.
2	Coal crushers	200 tons per hr.	Double roll	Link-Belt Co.
2	Coal elevators	200 tons per hr.	Overlapping pivoted buckets	Link-Belt Co.
2	Coal conveyors	200 tons per hr.	Belt	Link-Belt Co.
	Belts		Coal conveyor	Boston Woven Hose Co.
2	Weighing larries	20 ton		Heyl & Patterson, Inc.
21	Ash gates	5x5 ft	Air-operated	Baker-Dunbar-Allen Co.
4	Condensers	25,000 sq.ft. each	Surface	Westinghouse Elec. & Mfg. Co.
2	Stacks	21 ft. inside dia. 325 ft. above grates	Self-supporting steel	Amer. Bridge Co
3	Circulating pumps	44,000 gal. per min	Centrifugal	Westinghouse Elec. & Mfg. Co.
4	Condensate pumps	1,000 gal. per min	2-stage centrifugal	Westinghouse Elec. & Mfg. Co.
3	Air pumps	30 cu.ft. per min.	Le Blanc	Westinghouse Elec. & Mfg Co.
1	House-turbine set.	2,000 kw.	2300-volt, turbo-alternator	Westinghouse Elec. & Mfg. Co
2	Exciters	350 kw.	Duplex turbine and mtr. driven	Westinghouse Elec. & Mfg. Co.
2	Air washers	115,000 cu.ft. per min		B. F. Sturtevant Co.
2	Oil purifiers	100 gal. per min.	De Laval centrifugal	Turbine Eqpt. Co.
2	Intake screens	7½x54 ft.	Revolving	Chain Belt Co.
1	Traveling crane	75-ton main hst. 25-ton aux. hoist		Niles-Bement-Pond Co.
	Condensing-water gate valves		Motor and hydraulically operated	Pittsburgh Valve Fdry. & Construction Co.
1	Relief valve	25-in.		Pittsburgh Valve Fdry. & Construction Co.
2	Relief valves	42-in.		Atwood & Morrill
1	Flow valve	18-in.		Atwood & Merrill
7	Boiler-damper regulators		Balanced-draft	The Engineer Co.
3	Forced-draft fan controllers		Operated by blr. pressure	The Hagan Corp.
8	Boiler-feed controllers		Stets	Williams Gage Co.
6	Boiler-feed controllers		Copes	Northern Eqpt. Co.
7	CO_2 Recorders			Joseph W. Hayes Corp.
3	Boiler-feed pump governors			Edward Valve & Mfg. Co.
1	Recording pyrometer		Six-pen	Thwing Instrument Co.
7	Draft gages		Three-in-one	Precision Instrument Co.
14	Boiler-feed meters			Simplex Valve & Meter Co.
2	Indicating and recording-flow meters			Gen'l Electric Co.
2	Evaporator meters		Venturi	Simplex Valve & Mfg. Co.
18	Thermometers		Indicating & recording	The Foxboro Co., Inc.
7	Recording Gages			The Foxboro Co., Inc.
59	Indicating Thermometers			Taylor Instrument Co.
16	Pressure Gages			Ashton Valve Co.
	Float valves	12 in.		Golden-Anderson Valve Spec. Co.
1	Elevator		Psngr. and freight	Otis Elevator Co.
2	Lea recorders		Boiler-feed tank	Yarnall-Waring
2	Strainers			Elliot Company
2	Air compressors	500 cu.ft.	Motor-driven	Chicago Pneumatic Tool Co.

The remaining mechanical equipment, expansion joints, etc., were furnished by E. B. Badger & Son Co., Westinghouse Electric & Manufacturing Co., U.S. Rubber Co., and Pittsburgh Valve, Foundry & Construction Co.; miscellaneous pumps by Blackmer Rotary Pump Co., Yeomans Brothers Co., Worthington Pump & Machinery Co., Lawrence Machine Co., and Westinghouse Electric & Manufacturing Co.; miscellaneous valves by Pittsburgh Valve, Foundry & Construction Co., the Edward Valve & Manufacturing Co., the Chapman Valve Manufacturing Co., Fairbanks Co., and Golden-Anderson Valve Specialty Co.

Electrical power equipment was furnished by the Westinghouse Electric & Mfg. Co. Other electrical equipment was supplied by Western Electric Co.; Krantz Mfg. Co.; Electric Storage Battery Co.; Star Metal Box Co.; Crouse-Hinds Co.; Benjamin Electric Mfg. Co.; Holophane Glass Co.; Ohio Brass Co.; Standard Underground Cable Co.; Simplex Wire and Cable Co.; Habirshaw Electric Cable Co.; Q. P. Signal Co.; Delta-Star Electric Co.; James G. Biddle; Sibley Pitman. Fiber Conduit Co.; Keasby Mattison; and Johns-Manville, Inc.; Lapp Insulator Co.; Locke Insulator Manufacturing Company, Incorporated.



Troubles and Their Remedies in Multiple Operation of Direct-Current Generators

By Eustis H. Thompson

Proper Multiple Operation of Direct-Current Generators—Multiple-Operating Troubles Divided Into Nine Classes—The Various Troubles Are Given and Each One Analyzed—Both Generator, Turbine and Engine Troubles Are Discussed

STEAM engineers are frequently called upon to handle electric generators. After starting up and trying out a turbo-generator the next step in handling of such a machine is to try out multiple operation with other generators of the plant and make adjustments if necessary to secure satisfactory dividing of the station load. Such adjustments are not usually regarded as difficult. Sometimes troubles occur that must be referred to the manufacturer, and occasionally it is necessary to make expert tests and adjustments in order to produce satisfactory results.

It is not difficult to find descriptive matter in the various handbooks relating to the theory of multiple operation of generators. However, if trouble should be encountered in making adjustments, it would be a somewhat different matter to find written advice as to where to look for the trouble. An endeavor is here made to classify such troubles in relation to the symptoms that they indicate, so as to assist in locating the difficulty.

Good Multiple Operation

To begin with, proper multiple operation of direct-current generators is assumed to fulfill the following conditions:

1. Stable operation, or, in other words, the ability of the machine to be thrown in on the board, adjusted to the load, and taken off the busbars if necessary without undue surging and liability of blowing its own breaker or that of adjacent generators.

2. Ability to divide the load properly with other generators. This means that if all the generators are thrown on the busbars at no-load and the normal load of the station is then applied, the various machines will take their portions of the load in accordance with their capacity, so that a 100-kw. generator would be pulling twice as much as a 50-kw. generator, etc. Also, if the station load, when properly divided, is removed and the busbar load brought to zero, each generator would fall to zero load and would not pull a positive load at the expense of other generators being motorized.

3. A generator should handle its share of load without too much attention to the field rheostat by the station operator. It is supposed that an adjustment every two or three hours would be necessary under ordinary circumstances.

There is a distinction between good multiple operation and perfect multiple operation. Sometimes machines automatically pull their correct shares of the station load within 1 or 2 per cent without requiring any appreciable attention from the operator. This, however, is not the usual case and in most plants a variation of 10 to 20 per cent in the proper share of load between no-load and full-load is not objectionable. The main point is that the load should be properly divided at very light loads and at full loads, so that there will be no tendency to blow the breaker of one generator or motorize a machine at the aforementioned points. In plants where various makes and types of machine are used, both up to date and of older design, it would hardly be feasible to require too close adjustment of multiple operation.

Multiple-Operation Troubles Classified

The following compilation represents an effort to classify the multiple-operation troubles of compound interpole direct-current generators. This cannot be expected to represent a means of getting the exact answer to the question involved, as any special trouble will give symptoms in a somewhat different way, in different sizes and designs of machines. Many readers will doubtless recall conditions that this list does not cover adequately, and it is hoped that in such cases suggestions will be made covering those points.

Case 1

Circuit breaker opens instantaneously as soon as main switch is closed.

A. Violently with flashing at commutator, with serious arcs.

B. Bad flashing but no serious burns or arcs.

C. No abnormal flashing.

Case 2

Surge of current when the main switch is closed, which may or may not open circuit breaker.

A. Current rising directly and positively when main switch is closed with no abnormal sparking.

B. Same as A with noticeable sparking.

C. Current surging in an unstable and irregular manner, which may cause the circuit breaker to open immediately or in an appreciable time interval, or perhaps not at all.

D. Current surging in a regular and even manner, affecting the circuit breaker same as above.

Case 3

Over-compounding at heavy loads, no special surging.

A. No sparking.

B. With sparking.

Case 4

Under-compounding at heavy loads.

A. No sparking.

B. With sparking.

Case 5

Under-compounding or over-compounding, but not necessarily at full loads.

A. Sudden change coming quickly and unexpectedly, no surging.

B. Same as A with surging.

C. With sparking.

D. With mechanical vibration.

E. Same as D with flashing.

F. Gradual change in compound, or, in other words, gradual shifting of the load, either increasing or decreasing with no regular surging, which requires regulation of the shunt rheostat in order to carry the proper load.

G. Compound O. K. at full load. To much or too little at light loads. Regular and constant condition.

Case 6

Small surging or oscillating current.

A. Continual.

B. At intervals.

C. With sparking.

Case 7

Machine in good condition for a considerable period and then develops bad multiple operation, so as to under-compound. The foregoing change to take place gradually.

A. No surging.

B. With surging.

C. With sparking.

Case 8

Same condition as 7 except that a gradual over-compound takes place.

A. No surging.

B. With surging.

C. With sparking.

Case 9

Machine in good operation for a considerable period, when faulty multiple operation developed in a sudden and unexpected manner.

Probable Causes of Multiple-Operation Troubles

Case 1

A. General indication of reversed polarity between the machine and the busbars, due to a voltmeter which would read in a positive direction for a current which circulates in either direction, or a reversed polarity due to the voltmeter leads from the main switch being reversed; (2) short-circuits due to equalizer connected on positive side of generator and negative of other machines or vice versa; (3) grounds on opposite sides of the line.

B. Brushes shifted with or against rotation, which would represent an extreme case; (2) commutating trouble combined with other trouble of multiple operation.

C. Excessive excitation of the series field (over-compounding) due to (1) extremely low resistance of the series-field circuit; (2) open-circuit or poor connection in the shunt for adjusting series field, Fig. 1.

Case 2

A. Excessive excitation of the series field, as in Case 1—C; (2) very close regulation of the governor; (3) excessively high speed; (4) jerky action of the valve gear, due to sticking or lost motion at some point.

B. Brushes shifted off neutral; (2) reversed interpole field; (3) commutating trouble in combination with other multiple-operation faults.

C. Unstable surging is characteristic of equalizing trouble, such as: (1) Lack of equalizer; (2) high resistance of equalizer; (3) loose connection in equalizer; (4) loose connection in series-field shunt; (5)

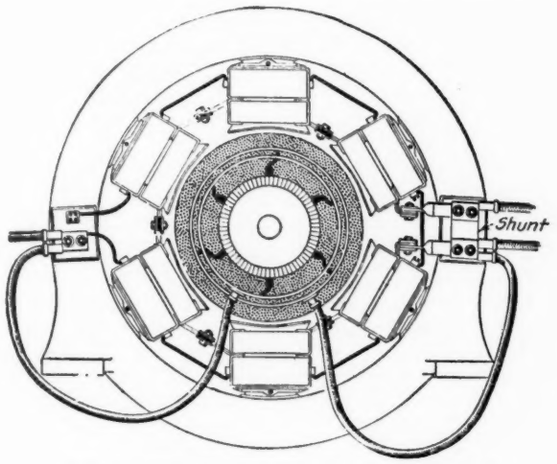


FIG. 1. COMPOUND-WOUND GENERATOR

too light a series field to give proper equalizing effect; (6) loose connection in the shunt-field circuit; (7) short-circuit in shunt-field circuit.

D. Surging of a regular and fairly even character is an indication of governor trouble due to friction, lost motion, too close regulation, or excessive weight in the moving parts of the governor and valve gear.

Probable points of such trouble are (1) sticking of dashpot; (2) sticking of pilot valve; (3) sticking of spring where it rubs on plug or other clamping element; (4) sticking at any other points of the valve gear.

Lost motion (1) in bearing, (2) governor stem, (3) hydraulic-cylinder piston, (4) other valve-gear points.

Case 3

A. General cause is over-excited condition of the series field as indicated in Case 1—C, except to a much less extent. (2) Excessive heating or loose connections in the compounding shunt; (3) brushes shifted too much against rotation (this would mean a slight shift only); (4) too close regulation of the governor; (5) too high speed.

B. Look for (1) brushes shifted against rotation to a large extent, (2) commutation trouble in combination with one of the foregoing causes.

Case 4

A. (1) Equalizer and series field connections to main switch interchange as at *A* in Fig. 2; (2) too heavy a series-field shunt; (3) excessive resistance of the main line, with possibly too low resistance of the equalizer; (4) ammeter placed in the series-field lead of the

machine or the equalizer lead instead of in the lead coming directly from the armature, which is the proper place; (5) too broad a governor regulation; (6) too low a speed; (7) inadequate steam supply, poor vacuum, or excessive back pressure on prime mover.

B. Brushes are shifted off neutral with rotation. (2) Commutating troubles in combination with one of the foregoing causes.

Case 5

A. Occasional short-circuit in the shunt-field rheostat; (2) equalizer and series-field leads crossed at the main switch; (3) charge of water coming over with the steam in a small machine; (4) sudden change of steam pressure, vacuum or back pressure; (5) ammeter sticking.

B. Loose connection in the equalizer circuit or the interpole-field circuit; (2) sudden accident or misadjustment in the governor or valve gear, such as spring vibrating in a high-speed governor, knife edges chipping, strainer or baffler and hydraulic gear stopped up, pin or bolt working loose, oil leaking, hot transmission bearing, etc.

C. Ground on some part of the machine, loose connection of the interpole circuit; (2) loose brush yoke.

D. Water in steam or in exhaust passage.

E. Loose joint in armature winding or shunt-field circuit.

F. This condition sometimes occurs on large interpole machines where the resistance contact of the brushes

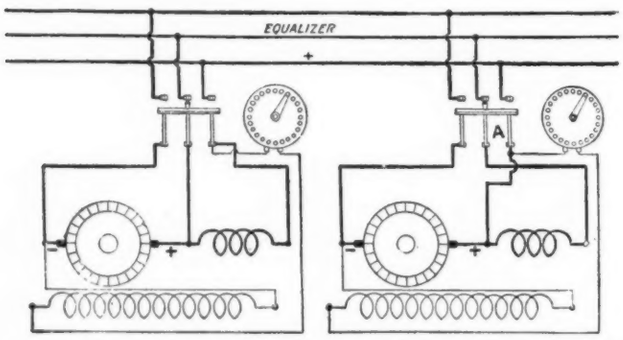


FIG. 2. TWO COMPOUND GENERATORS CONNECTED IN PARALLEL. CONNECTIONS AT A INCORRECT

is comparatively a large factor, and raises and lowers with a temperature of the engine room or with local drafts, due to doors or windows in the neighborhood of the machine. This can sometimes be remedied by inserting a resistance in a series-field lead of one or more machines, so as to increase or decrease the equalizer current. One of the surest schemes of prevention is to equalize on the interpole field, which should be avoided unless vitally necessary, as will be explained in a later article, under special cases.

G. Curve of voltage from no-load to full-load being different from the other machine. This is sometimes referred to as a voltage loop. It depends principally on the design of the machine and can sometimes be changed to advantage by changing governor regulation, speed, magnetic saturation, or resistance of series field and allied circuits. This is referred to in No. 9 at greater length.

Case 6

A. Continual and regular surging is generally due to the action of the governor or valve gear, as before noted. (1) If surging occurs during the entire range of load look for friction in the dashpot or some other part of the mechanism or lost motion; (2) surging at light loads, look for too close a governor regulation or too heavy moving parts or friction in the pilot valve.

B. Look for (1) loose connection or loosened part in some part of the valve gear, (2) loose connections in shunt-field circuit.

C. Too light a brush pressure; (2) brushes sticking in holders; (3) poor commutating position of brushes; (4) joint in the armature winding, which occasionally becomes loose and causes trouble, while during the rest of the time it carries current sufficiently well for good operation. For such loose joints note the condition of the commutator. The bar connected with this conductor will be blackened wherever the brush is touching.

Case 7

A. Ammeter reading low; (2) steam strainer becoming stopped; (3) buckets or nozzles becoming clogged with foreign matter or becoming eroded; (4) governor spring losing its elasticity, causing lower speed or broader governor regulation; (5) turns of the shunt-field winding gradually becoming short-circuited; (6) valve seats becoming worn causes overspeed at no load; (7) open-circuit or short-circuit developing in the shunt field.

B. Wear of bearings in governor or valve gear; (2) change of adjustment in governor or valve gear; (3) brush yoke slipping in direction of rotation a small amount.

C. Loosening of the interpole shunt; (2) insulation of the armature gradually burning out; (3) brushes slipping same as in previous paragraph.

Case 8

Over-compounding gradually occurring is very rare in ordinary experience.

A. (1) Loose connection in series-field shunt or equalizer; (2) misadjustment of the valve gear or wear of steam valves.

B. Same as A—1.

C. Loosening of the interpole shunt.

Case 9

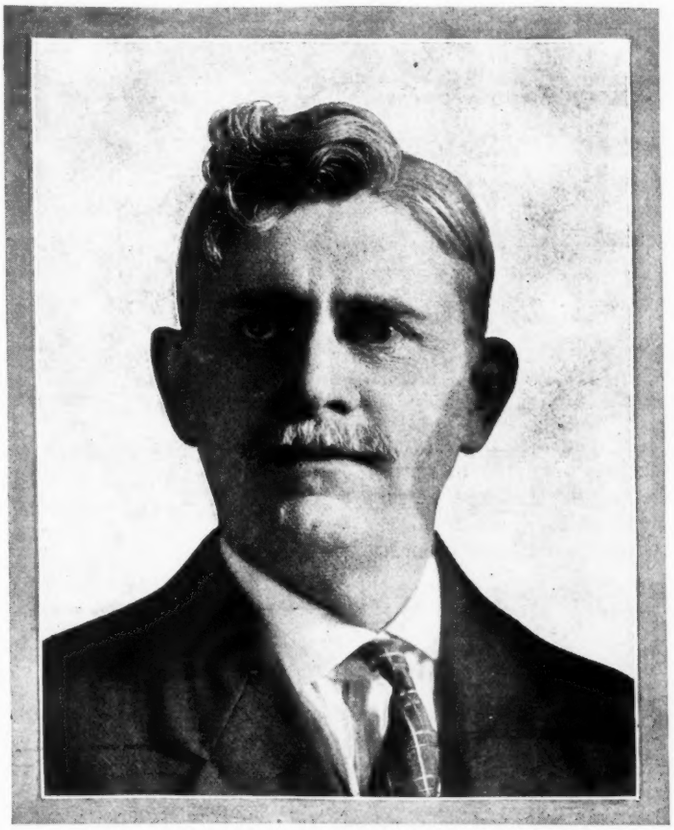
Changes which develop suddenly in reliable machines that have been well tried out, can be located only by carefully investigating the situation for causes or peculiar behavior that occurred at the time of such change. It often happens that in repair work or in cleaning by inexperienced men, the brushes are left improperly set or bolts improperly tightened or some similar error of doing the work has crept in. This is specially noticeable after repairs to governor or renewal of parts, which result in a different speed or governor regulation.

A substantial concrete floor laid on clay, or most any soil other than dry sand, becomes dangerous when heated to a temperature of more than 212 deg. F., for the moisture that collects under the floor is converted into steam by the heat, and there is probability of the floor being burst with great violence, due to the pressure under it. Specifying engineers of boiler installations should take into account the dangers connected with the use of concrete floors under boilers, when such floors are laid on soil that will not permit any steam formed under the floor to travel downward before any pressure substantially above atmospheric is generated. — *Warren Hilleary.*

John C. McCabe

Detroit's Director of Safety Engineering

AMONG the myriad of occupations brought on by an age of specialization the profession of safety engineering stands out as especially interesting because it is comparatively new and because it lies so close to the well-being of all of us, though we seldom realize the fact. John C. McCabe is a typical safety engineer; he stands in the foremost ranks of the profession, and so the story of his life and work is not only an absorbing narrative of personal achievement, but also really a description of the profession of safety engineering. Mr. McCabe has a dozen different jobs in the City of Detroit, but they all have the same purpose—the preservation of life and property. His title is "Commissioner of the Department of Buildings and Safety Engineering," and his work includes the supervision of building operations and of the inspection of electrical work, plumbing, boilers, elevators, smoke, refrigeration, inflammable liquids and illuminating gas, besides the issuing of licenses to engineers and boiler operators, electrical inspectors, supervisors of concrete construction and manufacturers of concrete blocks. He is also supervisor for Wayne County, and as a member of the State Board of Boiler Rules is responsible for the enforcement of the act passed in 1917 adopting the A. S. M. E. Code as the standard for boiler construction in the State of Michigan.



JOHN C. McCABE

During his long term of office he has personally examined over ten thousand men for engineer's licenses. The examinations are written and oral, and as a final safeguard the commissioner has a habit of asking a few leading questions. He is an adept at drawing men out and in a surprisingly short time arriving at an accurate knowledge of their capabilities.

In work to advance the engineering profession Mr. McCabe has always been active. He has served with the Boiler Code Committee of the American Society of Mechanical Engineers and has always been an earnest advocate of uniform boiler laws throughout the country. In 1910 he was responsible for the adoption of the Massachusetts boiler code in Detroit. He has taken an active part in engineering discussions on the safety of welded joints and is a corresponding member of the Casualty Council of the Underwriters' Laboratories. He is a member of the American Society of Mechanical Engineers, the Detroit Engineering Society, the Steel Treating Research Society, is an honorary member of the National Association of Stationary Engineers and a registered mechanical engineer under Michigan law.

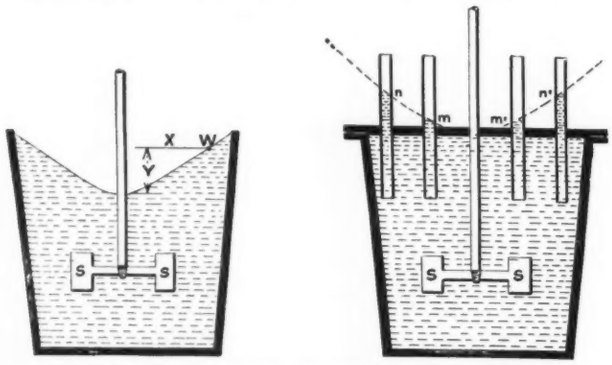
In 1882, when he was 18 years old, he started as an apprentice with George D. Walcott & Sons, manufacturers of machine tools. Three years later he went to Jackson Prison as assistant engineer and then chief engineer. Leaving that place in March of 1891, at the age of 27, he became chief engineer of the National Wheel Co. of Jackson, and a year later took a similar position with the Detroit Electric Light and Power Co. This plant had a capacity of 2,000 horsepower, which was large at the time. From 1893 to 1908 he served as either chief or mechanical engineer in a number of mid-Western plants, gaining a first-hand knowledge of practical engineering. Then he came back to Detroit and took a competitive examination for a five-year term as chief boiler inspector, the examination being conducted under the direction of the engineering department of the University of Michigan. He secured the appointment; later a civil service law placed the position on a merit basis and he has been there ever since.

In December, 1918, under the new charter for Detroit, Mr. McCabe was appointed by Mayor Couzens to the position by which he is best known—that of commissioner of buildings and safety engineering. Very recently he has been promoted, however, and in the future his work and title will be a little different. His new title is to be "Research Engineer for the City of Detroit," and his duties will include investigation of city activities along engineering lines. He is to retain his membership in the State Board of Boiler Rules and in the National Board of Boiler and Pressure Vessel Inspectors and has announced his intention of maintaining the same active interest in boiler matters in Michigan that he has shown in the past, and which has resulted in his being regarded as an authority on boilers, especially when safe methods of construction are involved.

Centrifugal Pumps—Part I. Elementary Theory and Classification*

By W. D. CANAN

ALTHOUGH the actual design of the various parts of a centrifugal pump involve rather difficult mathematical calculations, the principle of operation may be explained by means of a few simple illustrations. As the name indicates, centrifugal force plays a very important part in changing the mechanical work supplied to the shaft into kinetic energy of the



FIGS. 1 AND 2. SURFACE OF WATER IN MOTION

Fig. 1. Showing curved outline assumed by surface of water when it has been set in motion by stirrer *S*.

Fig. 2. Showing height to which water will rise in tubes placed at varying distances from center of closed vessel.

water. Let us consider first an open cylindrical vessel partly filled with water which has been set in motion at a rapid rate. Now the greater the distance of each particle of water from the center of the vessel, the greater will be its velocity, and since the kinetic energy

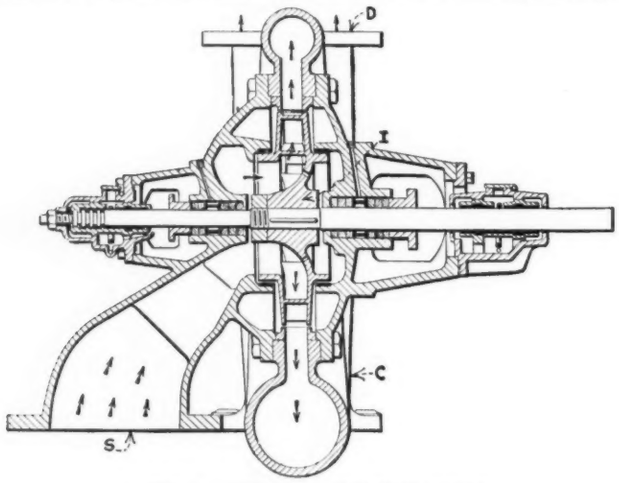


FIG. 3. TYPICAL VOLUTE PUMP

of a moving mass is proportional to the velocity, the kinetic energy of each of these particles will vary with its distance from the center of rotation. The unequal force thus exerted will result in the surface of the water assuming a curved outline, as shown in Fig. 1, depressed at the center and rising along the edges in the form of a parabola.

It can be proved that the height Y to which any particle X will rise is dependent on the velocity of rotation v. Suppose, now, the vessel is closed at the top and tubes communicating with the interior are attached as shown in Fig. 2. If the water is now set

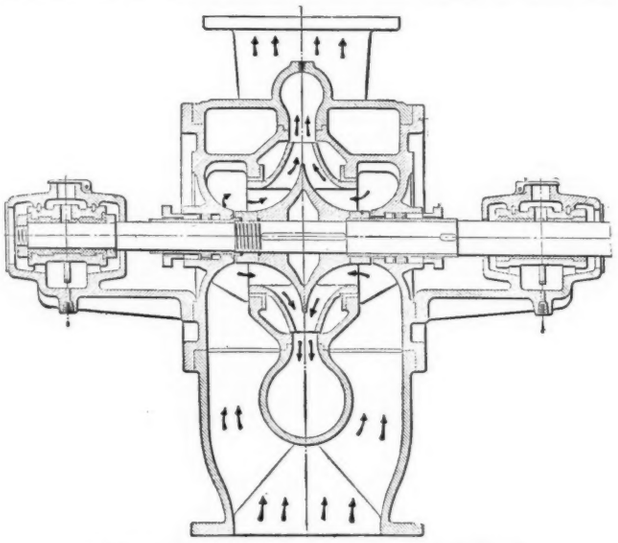


FIG. 4. DOUBLE-SUCTION VOLUTE PUMP

in motion, it will be found that it will rise to the levels indicated at m, n, m', n' and will tend to assume a curved outline as in the case of Fig. 1, for the reason

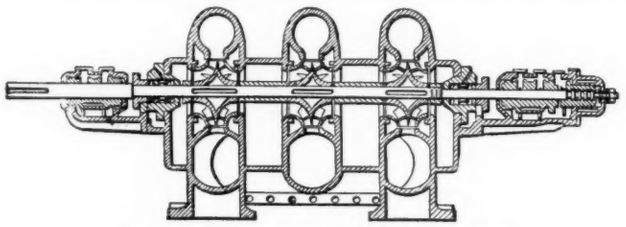
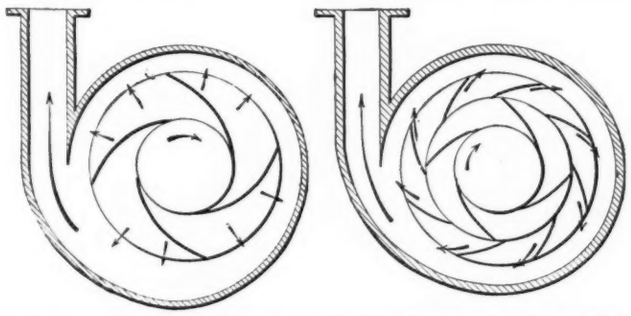


FIG. 5. MULTI-ROTOR VOLUTE PUMP

already given, and if water is supplied at the center of the vessel, a continuous flow will be produced out of any or all of the tubes. It is obvious, however, that



FIGS. 6 AND 7. SHOWING INTERFERENCE OF CURRENTS OBVIATED BY DIFFUSION

Fig. 6. Showing interference of water discharged from impeller and in casing of pump without diffusion vanes.

Fig. 7. Showing manner in which diffusion vanes direct the water discharged from the impeller.

in the case of an actual pump it would be desired to lift the water to as great a height as possible, and therefore only one connection is made for the water delivery.

*The second part of the article by Mr. Canan on "Centrifugal Pumps," treating of "Operating Efficiencies," will appear in an early issue.

The construction of a modern pump, although differing materially from these figures, is simple, consisting of a revolving fan or impeller of several blades attached to a shaft and turned by some external force.

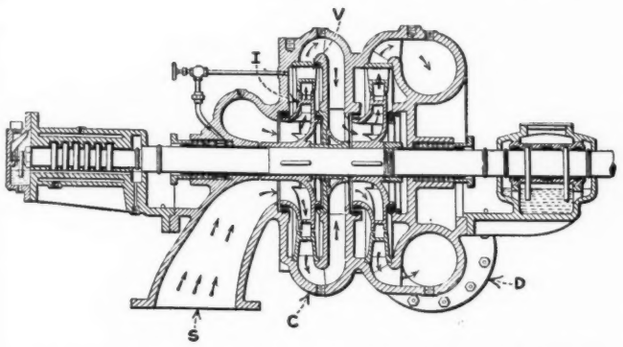


FIG. 8. TWO-STAGE SINGLE-SUCTION TURBINE PUMP

This impeller is fitted to a casing so constructed that the water will enter at the center of the wheel either under pressure or drawn up by suction. The delivery or discharge is taken off at the outer part of the casing and tangentially to the path of the revolving blades.

VOLUTE-TYPE CENTRIFUGAL PUMPS

Centrifugal pumps are generally classified as volute and turbine. Fig. 3 shows a sectional view of a typical volute pump, *S* being the suction line, *I* the impeller, *C* the casing and *D* the discharge. Water entering the suction line is picked up by the impeller and given a whirling motion. As it leaves the blades, it passes around the casing with gradually reducing velocity and increasing pressure. The casing is made in the form of a spiral or volute in order that the pump may discharge around the entire circumference of the impeller and also that some of the velocity head may be converted into pressure head.

It is sometimes desired to increase the capacity of the pump without increasing the diameter of the impeller. This is accomplished by constructing the impeller so that it takes water on both sides, as illustrated in Fig. 4, instead of on one side as shown in the previous figure. Such a design is known as a double-suction impeller pump, and will have approximately double the capacity of the same size of pump in which the impeller is only single-suction.

Where very large capacities and high rotative speeds are required and it is not possible to meet these conditions with a single double-suction pump, recourse is had to what is known as the multi-rotor volute pump, Fig. 5. It can be seen that this construction is in reality three double-suction impellers with a common suction and discharge line, all inclosed in the same housing.

TURBINE-TYPE CENTRIFUGAL PUMPS

Where it is desired to lift water to a height greater than 100 to 150 ft., it is found that the volute pump cannot be used to do the work efficiently owing to the fact that the water does not leave the impeller in the same direction as the water passing around the casing. The interference resulting is illustrated in Fig. 6. The effect of this interference is not so noticeable for heads lower than those mentioned because the velocity of the water leaving the impeller does not need to be so great as when higher heads are to be overcome. In turbine pumps this defect of the volute type is eliminated by placing so-called guide or diffusion vanes around the impeller so as to direct the water discharged from it parallel to that in the casing, as illustrated in Fig. 7. Otherwise the construction is similar to that of the volute except that the casing, instead of being shaped like a spiral and of varying cross-section, is usually made concentric with the shaft. Although a single-impeller turbine pump may be used to develop very high heads, it is better practice to divide the pressure between two or more impellers or stages, and Fig. 8 shows a two-stage turbine pump of a single-suction type, in which water enters through the suction line *S*, passes to the impeller *I* and is discharged through the diffusion vanes *V* into the casing *C* on the first stage, thence down toward the shaft to the second impeller, through the guide vanes, and finally out (*D*) the discharge line. Approxi-

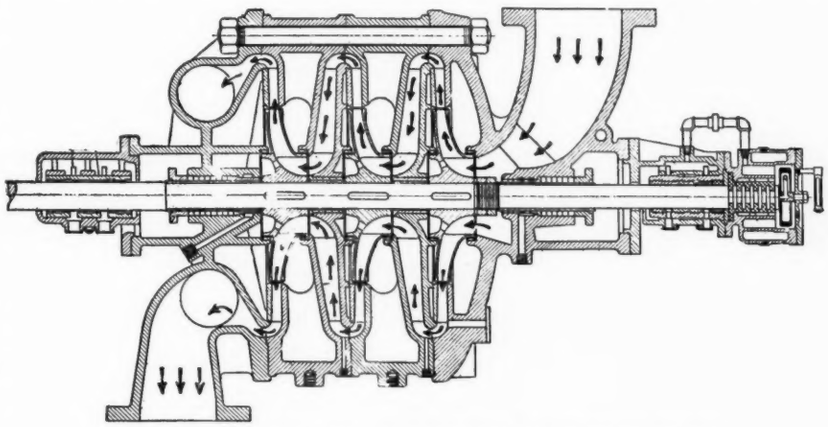


FIG. 9. THREE-STAGE SINGLE-SUCTION TURBINE PUMP

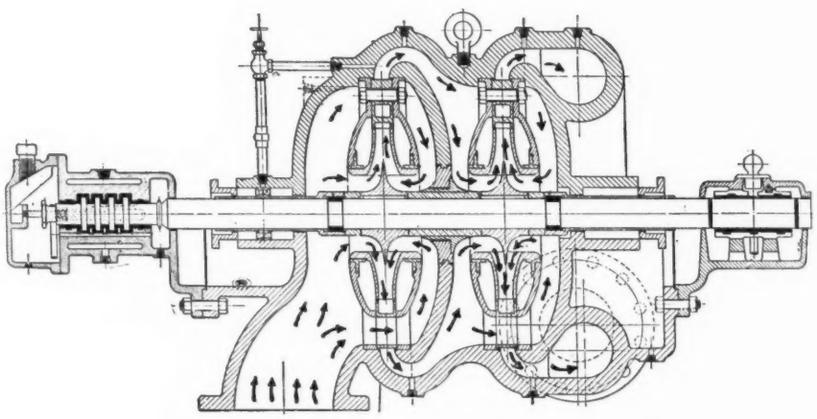


FIG. 10. TWO-STAGE DOUBLE-SUCTION PUMP

mately half of the pressure will be developed in each of the stages of a two-stage pump, one-third in a three-stage, etc., the pressure per stage not running much over 75 lb. per square inch.

Fig. 9 is a sectional view of a single-suction three-stage turbine pump, the view showing plainly the diffusion vanes and impeller.

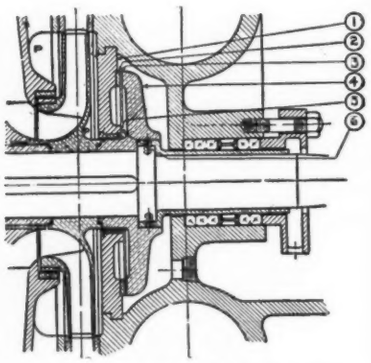


FIG. 11. AUTOMATIC WATER BALANCING DEVICE

As in the case of the volute pump it is often necessary to have large-capacity turbine pumps with relatively high rotative speeds for electric-motor or steam-turbine drive. Fig. 10 shows a two-stage double-suction pump that has this feature, the construction of the impeller enabling it to take water on both sides. Turbine pumps of four, five or even more stages are made, depending on the pressure to be developed.

An inspection of any of the illustrations of either the single-suction volute or turbine pump will show that the water pressure on both sides of the impeller is not the same. To take care of this thrust of the shaft, thrust bearings are used or automatic water balancing is resorted to. The operation of one of the automatic water-balancing devices may be explained as follows, referring to Fig. 11:

The pump generates a total pressure p, which builds up a pressure slightly less than p in the pressure chamber 5 due to leakage through the space 6. This pressure acts against the balancing piston 4 to counterbalance the end thrust, which is in the opposite direction. If this balancing force overbalances the end thrust, the leakage joint 3 opens slightly, allowing the escape of a small amount of water, thereby reducing the pressure in the space 6 and allowing the shaft to return to a position of equilibrium. The slight end movement of the shaft is noticeable only in starting up, as the shaft takes up and remains in a balanced condition when the pump is operating.

Many of the larger pump manufacturers, however, still prefer to rely on thrust bearings or collars to take care of this end thrust, rather than upon any automatic arrangement.

Chicago's New Central Station*

THE new Calumet Station now being erected by the Commonwealth Edison Co. is located just north of One Hundredth Street, on the Calumet River in the industrial district of South Chicago, and will take care of the southeastern section of Chicago. The site has an area of forty-three acres to give space for large coal storage and provide for future extension. Plans have been made for a six-unit station, but at the present time only two 30,000-kw. units are going in. The power-plant buildings are to consist of a switch-house, transformer house, turbine room and boiler house. Just enough of the new structures are to be completed to house the first two units.

Numerous features in the design of the station place it a step in advance over other plants of the company. One of these features is the ever-increasing area occupied by the boilers and coal-handling equipment. At Calumet Station they will require 65 per cent of the total building area. The boilers are of the B. & W. Alert cross-drum type with 20-ft. tubes 4 in. in diameter. Each contains 15,089 sq.ft. of steam-making surface. They are built for 350 lb. pressure and 250 deg. superheat and will have 4,000 sq.ft. of superheating surface. Four boilers per unit is the plan, but the first two units are to be served by seven boilers of the size previously given. The guaranteed evaporation from each boiler is 150,000 lb. of water per hour, amounting to about 300 per cent of normal rating.

There are to be two forced-draft Coxe chain-grate stokers per boiler having an active area of 376 sq.ft. and a ratio to the steam-making surface of 1 to 40. With a headroom of 20 ft. from the grate to the tubes, the furnace of each boiler will have a volume of 6,700 cu.ft., which reduces to nearly 18 cu.ft. per square foot of grate area, or to 0.36 cu.ft. per pound of coal burned per hour, figuring on a combustion rate of 50 lb. of coal per square foot of grate per hour. The steel stacks serving the boilers will be considerably shorter than at the other stations. They will be 16 ft. in diameter and rise 167 ft. above the grate. Forced-draft fans, each having a capacity of 50,000 cu.ft. per min., will serve the boilers, and the induced-draft fans drawing the gases from the economizers will require 200-hp. motors to drive them.

Economizers with steel tubes and steel headers will be installed. There will be one per boiler containing 9,600 sq.ft. of surface split up into three sections with the tubes running crosswise with the boiler tubes. In the use of these economizers a net gain of about 10 per cent in economy is anticipated, adding about 7 or 8 per cent to the possible 74 or 75 per cent obtainable from the boilers without the economizers. To guard against the condensation of sulphurous-acid gases on the steel economizer tubes the temperature of the feed water before entering the economizer is to be raised to 175 deg. At this temperature any condensation of sulphurous gases will be avoided and the life of the economizer prolonged. To obtain this temperature sufficient steam will be bled from the lower stages of the main turbines.

In addition to the economizer an air preheater of the plate type is under consideration. The gases will leave the economizer at about 350 deg. F. By the use of the preheater their temperature would be reduced over 100 deg. and the air for the boiler furnaces preheated to about 200 deg. F. As a better generator of sulphurous acid could scarcely be obtained, when coal containing nearly 5 per cent of sulphur is being used, the installation of the preheater is doubtful, although one of these preheaters may be given a tryout.

Continuous bucket elevators will be used to elevate coal to the level of the overhead bunker, and from here belt conveyors will distribute it to the bunker. In

*From a description furnished by A. D. Bailey, superintendent of generating stations, Commonwealth Edison Co., before the Western Society of Engineers and the Chicago Section A. S. M. E. April 18, 1921.

crushing the coal an innovation is to be the use of a Bradford breaker which is unusually heavy and substantial and will automatically pass out the scrap iron, slate, etc., which so frequently put out of action the roll-type crushers employed in the other plants of the company. Ashes from the hopper under the stoker will be dumped directly into railway cars at grade, as the plant has been built at sufficient elevation to permit this practice.

One of the two generating units now being installed is a seven-stage G-E machine having highest economy at three-quarter load. Steam is to be delivered to the turbine at 300-lb. and about 225 deg. superheat, giving a final steam temperature of approximately 650 deg. The speed is 1,800 r.p.m. The other turbine is a tandem-compound Westinghouse machine of the same type as installed at Northwest Station. The speed of this machine is 1,200 r.p.m. Both turbo-generators are rated at 30,000 kw. at 85 per cent power factor. Three-phase 60-cycle current will be generated at 12,000 volts. Two 33,000-volt cable lines will connect the new plant with the Fisk Street and Quarry Street stations. Incidentally, this is the highest voltage ever carried in a cable.

Each turbine will be served by a surface condenser containing 52,000 sq.ft. of surface, or about 1.73 sq.ft. per kilowatt of generator rating. The circulating pump will have a capacity of 55,000 gal. per min. It will be motor-driven, as will be all auxiliaries in the plant with the exception of the boiler-feed pumps. Three of the four pumps installed will be turbine-driven. For operating the oil switches 230-volt direct current will be used and 2,300-volt 60-cycle alternating current power for auxiliary motors above 50 hp. For the smaller motors 440-volt service will be provided. The use of high voltage alternating-current service on the larger auxiliary motors is an innovation for the company.

In the condenser special washers are to be provided, which will allow cleaning the condenser while in operation. To reduce hand labor, there will be double sets of revolving screens at the intake for condenser-circulating water. In the other stations double sets of stationary screens and one revolving screen had been employed.

At the new station it is anticipated that the fuel cost will form about 86 per cent of the station generating cost and that a kilowatt-hour will be produced on 19,000 B.t.u.

Draft is caused by a difference in pressure. When draft is created solely by a chimney, this difference in pressure is effected by the difference in weight between the column of hot gases in the chimney and an equal column of air at atmospheric temperature. This difference in weight causes a flow of air to the chimney. In its course to the chimney the air passes through the fuel bed, is heated, and the flow of air is kept up constantly as long as a fire is maintained.

When two small pop safety valves are used it is easier to keep them tight. There is less danger of lifting water if the valves should blow when the water is high in the boiler. Firemen will regulate drafts more readily to prevent the second pop from blowing. In the event of one valve leaking it may be taken off, with suitable arrangements, repaired and the boiler run with one valve while the other is being repaired.

A Telephone Connection with Watchman System

By W. A. Harris

It is proposed to provide a telephone connection at each "ringing" box or station on the electric watchman's system, so that in case of fire, steam or water leak, or if help is needed for any reason, the watchman can immediately get in touch with the engineer on watch without breaking his rounds. The cost of adding this device to the watchman's system is small and the work may be easily installed. Most watchman's systems are of the magneto-operated type, one station on each floor of small buildings and two or three per floor in buildings with large floor space. There is a "common" wire that connects all these stations to a recorder, which is generally placed in the engine room, and one wire from each magneto direct to the recorder. As shown in Fig. 1, a plug receptacle or floor push is mounted in a block of wood under each magneto box. One side is connected to the station common and the other to the corresponding terminal on all the other plug switches and through a battery of dry cells to a telephone in the engine room, as shown in Fig. 2. The telephone is connected between the battery and the station common. The watchman carries a telephone set with a plug to fit the receptacles as shown in Fig. 1. He can plug in at any station and, by pushing the button, rings the phone in the engine room. He can in his way send in an alarm or deliver any required message without leaving his beat.

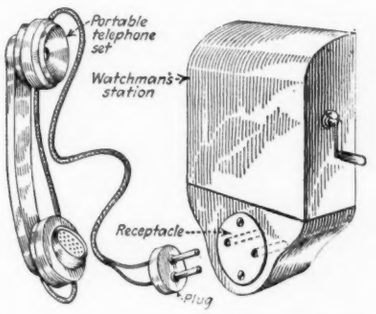


FIG. 1. TELEPHONE CONNECTION FOR WATCHMAN'S STATIONS

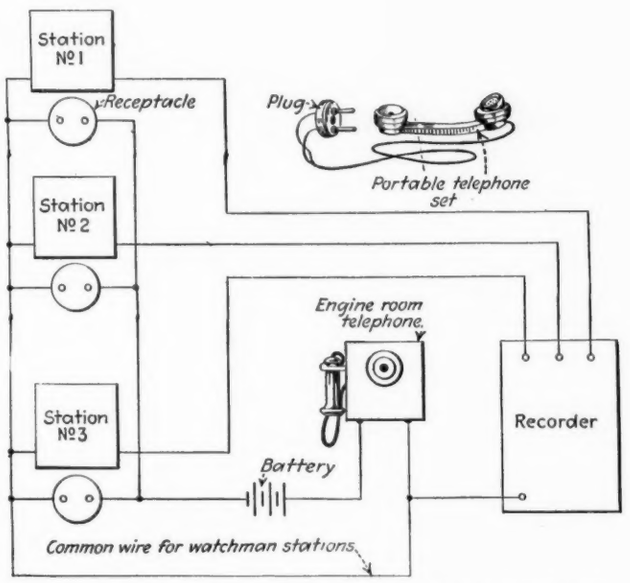
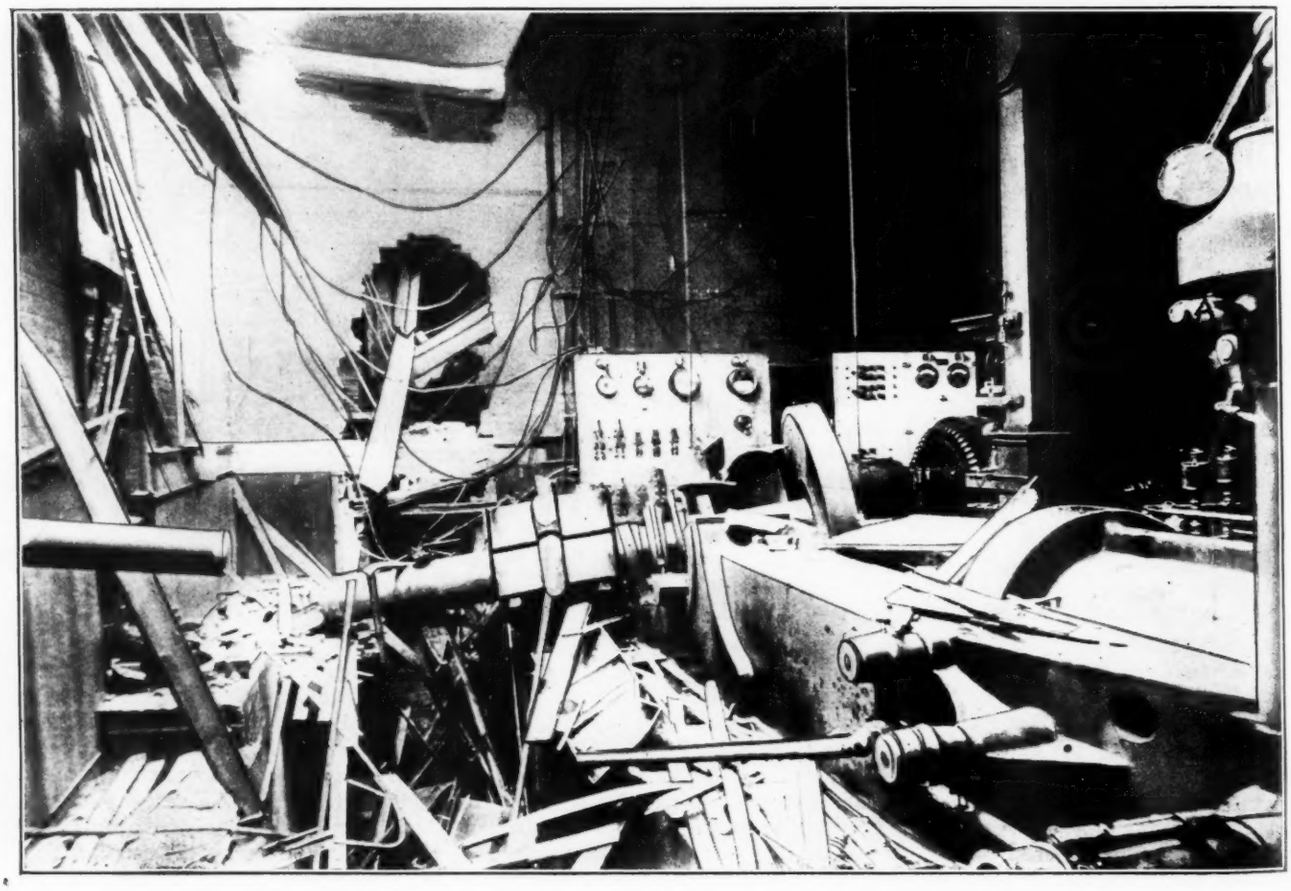
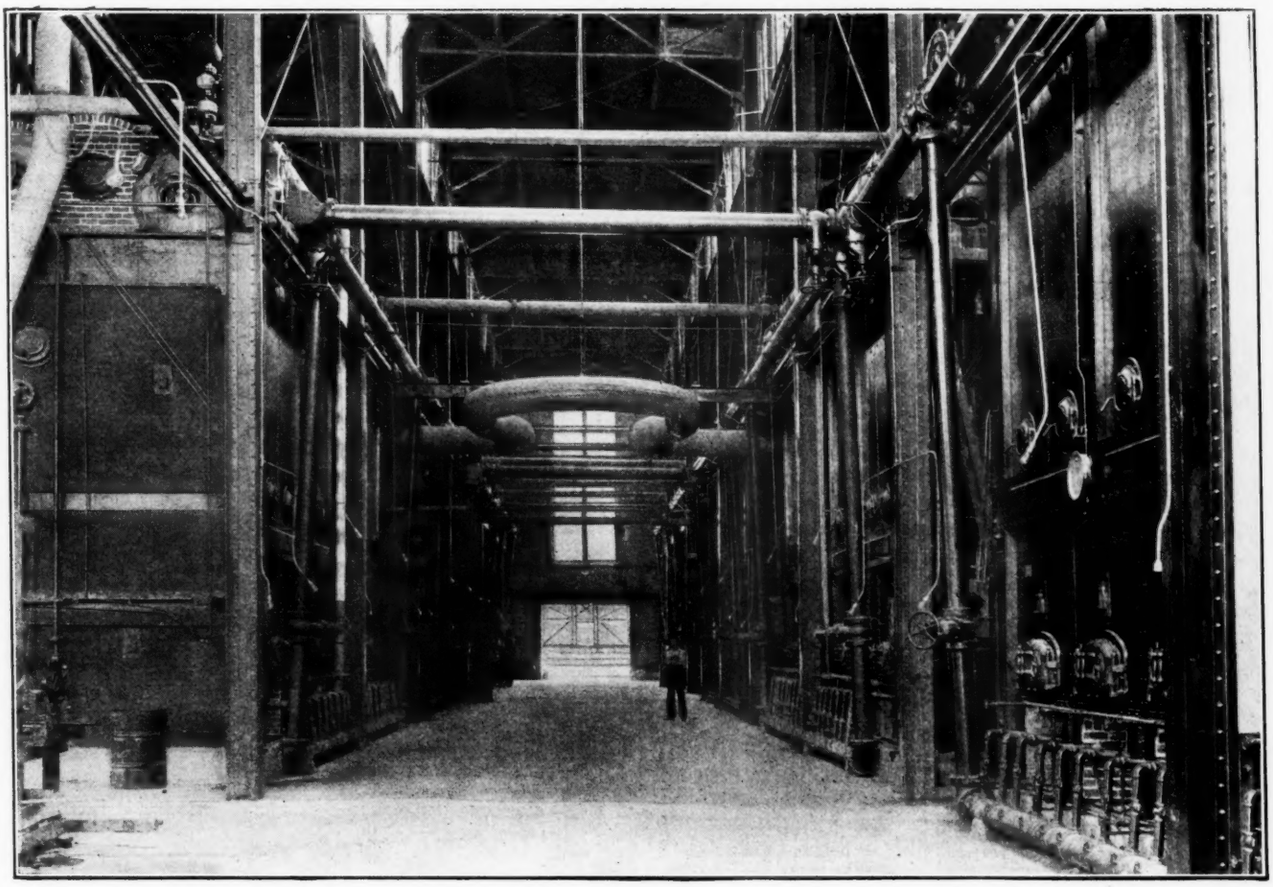


FIG. 2. WIRING DIAGRAM OF COMBINED WATCHMAN AND TELEPHONE SYSTEM

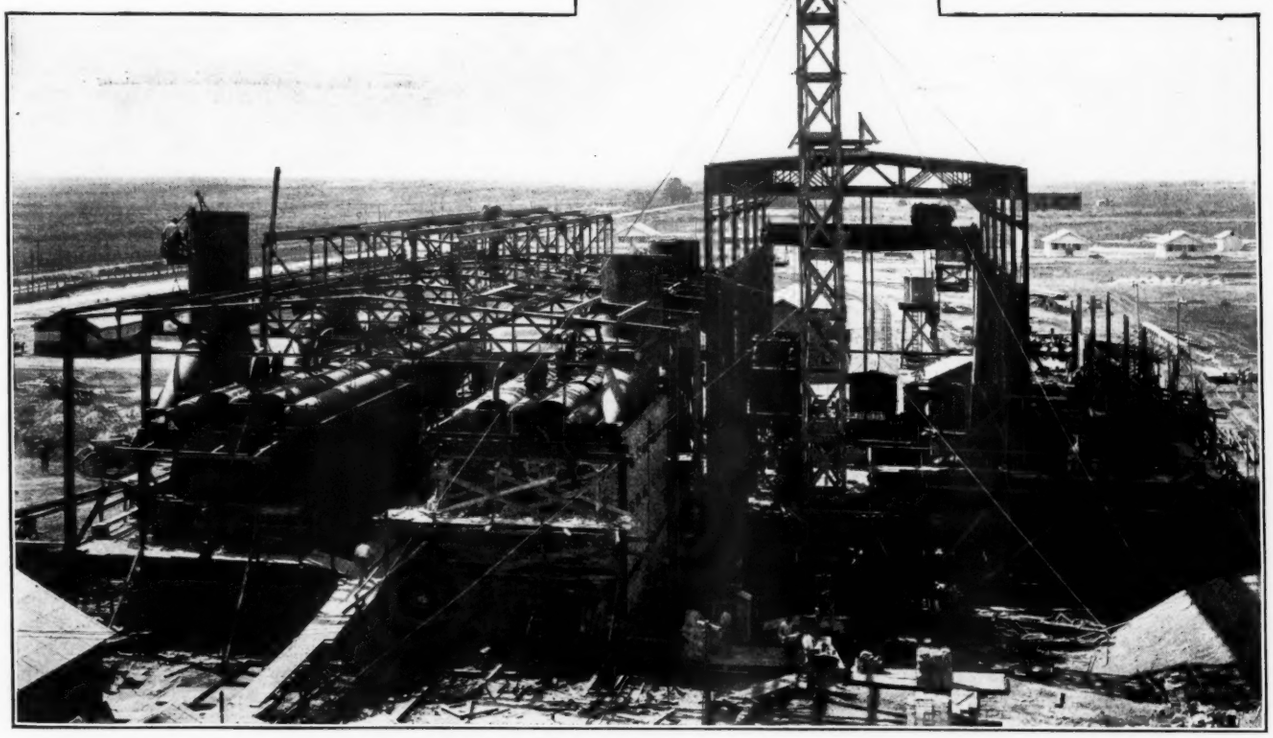
The wreckage shown here is the result of a flywheel explosion in the shop of the Trippensee Manufacturing Co., of Detroit, Mich., on April 7. Indications are that it was caused by sudden throwing off of the load, acceleration of the engine causing the governor belt to slip, so that before the governor could speed up enough to throttle the engine, the flywheel gave way. The letter A in the lower view shows where connection was made from the safety stop to the lever arm actuating a rider pulley, the purpose of which was to trip the governor in case its belt should break or come off. As the belt apparently slipped, but did not come off, this device could not function. The engine was a 750-hp. Corliss, with a normal speed of 90 r.p.m. and it had been in use for 18 years. The wheel was 18 ft. in diameter with a 37-in. face and was strongly reinforced. It was made in halves, securely fastened by bolts. The belt was 4 in. wide, only a few months old, and in good condition. A piece of the wheel weighing about 550 lb. was hurled 500 ft. and the engine was practically demolished, but neither the engineer nor anyone else was seriously injured.





The natural gas-burning steam plant of the San Joaquin Light and Power Corp. at Buttonwillow, near Bakersfield, Cal., work on which is being rushed to completion to enable the plant to be cut in early in May. The photograph shows the progress up to March 8. The boilers, which are 8,220-sq.ft. Stirling units, were practically erected before the steel building frame was up. The first generating unit will have a capacity of 12,500 kva. and will operate at 11,000 volts. (Below.)

Provisions for burning either oil or natural gas are a feature of this boiler room in the Bakersfield Steam Plant of the San Joaquin Light and Power Corp. Gas is now being used here in quantity. Note the double set of piping for the two kinds of fuel. (Above.)



A New Type of Indicator for High-Speed Internal-Combustion Engines

By PROF. AUGUSTUS TROWBRIDGE
Member National Research Council

New diagram, electrically transmitted, shows velocity of cylinder pressure changes at every instant instead of actual pressures. Usual form for ascertaining power consumption may be constructed mathematically from it.

WHEN one thinks of the important rôle played by the steam-engine indicator in the development of the modern steam engine, one is surprised that in the development of the modern high-speed internal-combustion engine the indicator has played so small a part. Improvement in the internal-combustion engine has been directed more toward greater flexibility and reliability in use by amateur operators than toward greater economy in operation of large units by professional engineers. From what appear to have been purely empirical methods has been evolved a satisfactory general type of motor for automotive purposes, the various examples of which put out by the various makers differ but little in what are regarded as the main features of design. The relative importance of these main features of design is, however, more a matter of inference from block tests of over-all engine efficiency and thermodynamic considerations based on supposititious cylinder conditions than of experimental study of the actual conditions existing in the cylinder at every instant during the cycle.

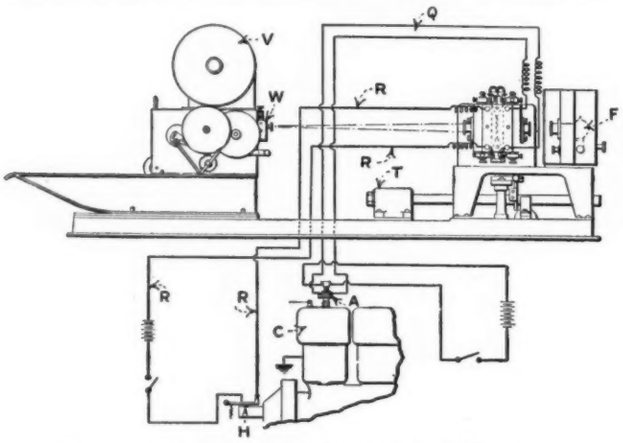


FIG. 1. DIAGRAM SHOWING ARRANGEMENT OF INDICATOR AND RECORDER

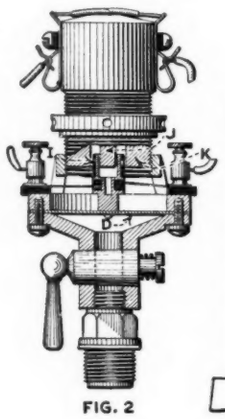


FIG. 2

FIG. 2. THE INDICATOR

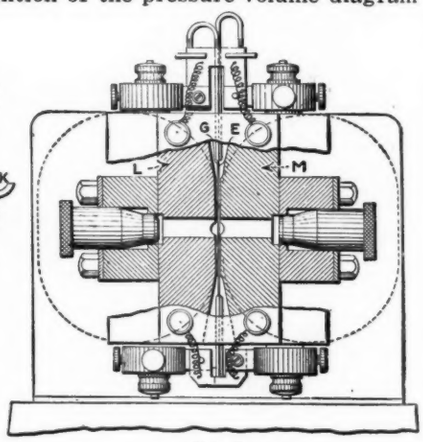


FIG. 3

FIG. 3. DETAILS OF RECORDER

Early attempts to ascertain these conditions by the use of indicators were not encouraging, chiefly because engineers employed either the existing steam-engine indicator or special indicators of the steam-engine type which retained many features that rendered their use misleading when employed at speeds far in excess of those for which they were designed. It is, of course, quite evident that an indicator, the inertia of whose moving parts would introduce no errors at one hundred revolutions per minute, might be utterly unreliable when used at 2,000 r.p.m., and this failure of the standard type of indicator to admit of adaptation to the needs of the automotive engineer has probably done much to restrict its use and that of the types of indicator more suitable for internal-combustion engines, which have been devised in recent years. These latter, for the most part, retain the feature of the steam indicator of linking the card to the piston so as to furnish a diagram in which the pressure in the cylinder at any instant is plotted as a function of the volume that the hot gases exerting this pressure occupy at this same instant. This has the advantage that it furnishes a pressure-volume diagram with which engineers are familiar and from which it is easy to derive the indicated horsepower by measuring the area of the surface inclosed by the lines of the pressure-volume cycle. There are, however, certain disadvantages which result from a retention of the pressure-volume diagram in work with high-speed internal-combustion engines which will be pointed out and discussed later in this article.

The chief improvement of the more modern indicators over the original steam-engine type consists in the reduction of the inertia of the moving parts which has been accomplished by the substitution of a steel diaphragm for the small piston, with a tiny mirror, the suitable connection of which to diaphragm and crankshaft produces a rotating effect about two axes, and consequent projection by a pencil of light upon ground glass or sensitized tape of a curve, the co-ordinates of which are the pressure at any instant in the cylinder and the corresponding value of the volume occupied by the gases exerting this pressure at the same instant.

The writer has not used the commercial form of this indicator, though he has studied a great number of photographic records obtained through its use. On the whole, the performance of the instrument seems to be good except that (a) a very slight lost motion in the mounting of the mirror may cause the photographic record to show spurious loops; (b) the jar of the

engine to which the recording mechanism is rigidly attached is communicated to the spot of light and the trace of this is not so fine a line as it could otherwise be; (c) on account of the size of the entire assembly it cannot be easily mounted close enough to the engine cylinder to avoid waves being set up in the pipe connections, which must be neither too small nor too large to assure a true pressure record.

There is no simple means of electrically transmitting a record of the actual position of a moving body, but it is an extremely simple matter to transmit a record of its velocity at every instant of its motion. From a record of its position at any known instant and its varying velocity at each and every succeeding instant, it is a simple geometrical matter to find its position at each and every instant. Electromagnetic induction furnishes a simple means of recording the velocity at which a body is moving—the current induced in a small coil attached to the moving diaphragm, and so mounted that any one of the circular turns of the coil lies in a magnetic field radiating from the center of the circle, is proportional to the velocity with which the turn (or turns) of wire move in the direction at right angles to the plane of the magnetic field.

In Fig. 1, which shows in diagrammatic form the general arrangement of indicator and recorder, the indicator is shown at *A* mounted on one of the cylinders *C* of a gasoline engine. Fig. 2 shows an elevation (partly in section) of the indicator; the coil referred to is shown at *I* and the diaphragm to which the coil is rigidly attached at *D*. The internal pole of the magnet providing the field which runs radially through the coil is shown at *J* and the other (ring-shaped) at *K*. As will be seen from Fig. 2, an up and down motion of the diaphragm *D* causes the coil *I* to

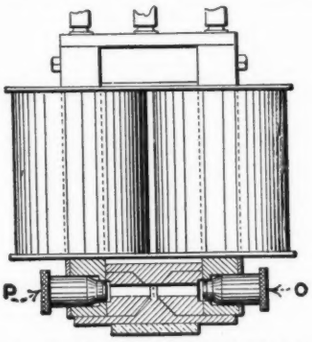


FIG. 4. PLAN OF RECORDER MAGNET

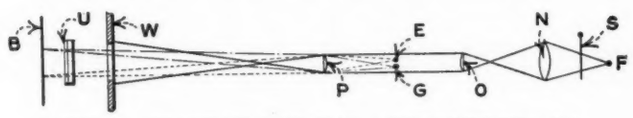


FIG. 5. DIAGRAM SHOWING ARRANGEMENT OF RECORDER LENSES

move across the radial magnetic field and by this motion to induce currents in the circuit of the coil which are in one direction as the diaphragm rises, in the opposite direction when the diaphragm falls, and zero when the diaphragm is at rest in any position.

To record this current it is conducted through a very fine wire about 0.0004 in. in diameter, shown connected to the coil by the wires *Q* of Fig. 1 and as *E* in Figs. 3 and 5. This fine wire is mounted between the poles *L* and *M* of a powerful electromagnet and at right angles to the direction of its uniform magnetic field. When a current flows in wire *E*, it is urged at right angles both to its own length and to the direction of the field of the electromagnet or at right angles to the plane of the drawing.

Fig. 4 is a plan of the electromagnet which shows how the polepieces are shaped so as to provide an intense magnetic field in the region in which the fine wire is stretched, and Fig. 5 a diagrammatic sketch

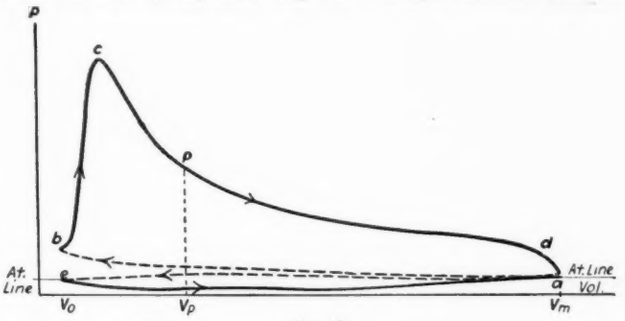
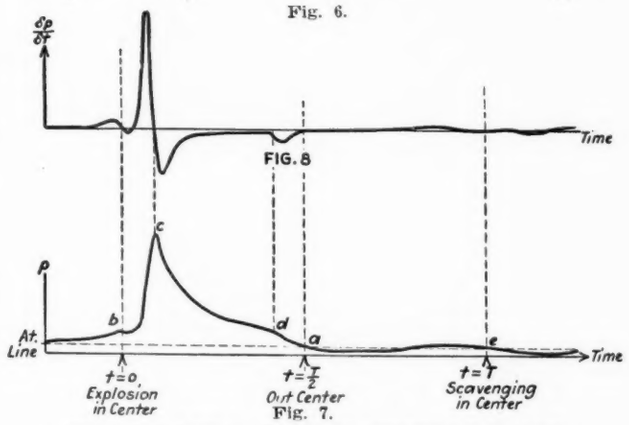


Fig. 6.



FIGS. 6, 7 AND 8. TYPICAL CURVE DIAGRAMS

in plan. If the current in the wire flows in one direction, it is urged from the position *E*, Fig. 5, toward the position *G* and vice versa, while by means of suitable lenses *N*, *O*, *P*, *U*, Fig. 5, for illumination and concentration of the light from the electric bulb *F*, a shadow of the fine wire may be made to appear as a tiny black spot in an illuminated field of light on the face of a recording camera *W*, Figs. 1 and 5, and motion of this spot photographed on a strip of sensitized paper *B*, Fig. 5, which is fed through the camera in which it is automatically developed, fixed and washed, and delivered in a form suitable for filing.

The advantages of this electromagnetic method of recording the motion of the diaphragm subjected to the pressure existing in the engine cylinder are: (1) The light coil of wire attached to the diaphragm does not seriously affect its motion; (2) there are no mechanical linkages or leverages to cause lost motion; (3) jars to the engine are not transmitted to the recording mechanism either mechanically or electrically; (4) the motion of the fine wire causing the shadow-photograph is strictly proportional to the velocity of the diaphragm to which it is electromagnetically connected, and because of its extreme lightness there are practically no inertia effects; (5) owing to the absence of vibration of the electromagnetic transmission there is a clearness and sharpness of the resulting record which makes it easy to read and interpret.

The objection to the electromagnetic method of recording is that it does not show the pressure at every

instant of the stroke, but rather the rate of variation of this pressure with the time at every instant. As explained further on, it is purely a matter of simple geometry to convert this form of record into that in which the pressure is given as a function of the time if it is so desired. The experience of the writer has been, however, that this geometrical transformation is by no means necessary, as one quickly acquires a facility in interpreting the original record so that quite as much, if not more, information may be obtained from it as from a record of the pressure with the time. For quantitative, as distinguished from comparative work, however, such as measurement of indicated horsepower, it would be necessary to convert by a simple geometric construction the record directly obtained into the standard form of indicator diagram. If it is not desired to obtain a quantitative value of the indicated horsepower, but merely to compare the explosions in a cylinder under different working conditions or to compare the explosions in the several cylinders of an engine, or to determine accurately the effect of slight changes in the timing, lift, etc., of the valves, or in the timing of the ignition, it is not only unnecessary to convert the original experimental records into the standard indicator-diagram form—it is actually easier and more accurate to make measurements on the original records.

In order to determine the position of the crankshaft with reference to the pressure record produced by the fine wire *E* already described, another and similar wire *G*, shown in Figs. 3 and 5, is located close to and parallel with *E*, so that when in normal position

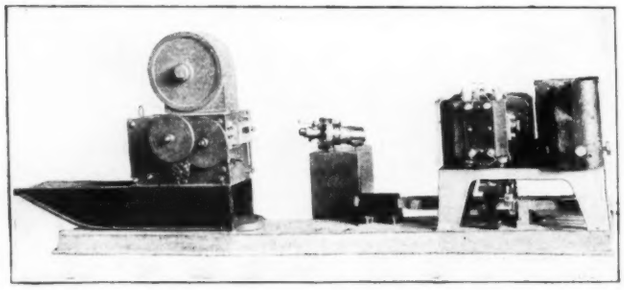


FIG. 9. INDICATOR ON ITS SIDE ON A BOX

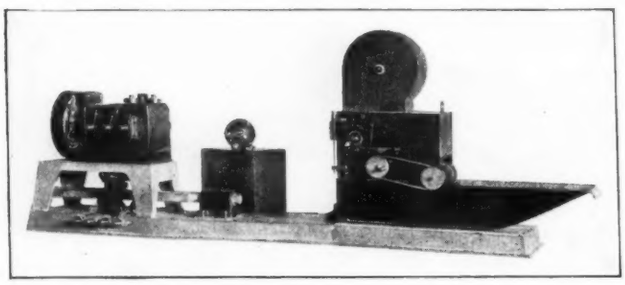


FIG. 10. REAR VIEW OF PARTS SHOWN IN FIG. 9

its presence would be indicated on the record tape as a straight line. As indicated at *H*, *R*, Fig. 1, however, this wire is in circuit with an auxiliary dry battery provided with a circuit closer operated at every revolution of the engine shaft, thus making an indentation or "jog" for reference purposes.

Another automatically operated time-recording feature comprises an electrically energized timing fork shown at *T* in Fig. 1, which, acting through the fields of a tiny alternating-current motor, controls the speed of a wire-spoked rotor indicated at *S* in Fig. 5, which by means of the cylindrical lens *U* projects a sharply defined shadow on the sensitized ribbon at intervals of $\frac{1}{100}$ second, resulting in a series of transverse lines in the completed record, which therefore contains (a) the time scale, (b) the time marks indicating the piston position, and (c) the curve showing pressure variations within the cylinder.

Figs. 9, 10 and 11 in conjunction with the diagrams show quite clearly the various parts of the actual ap-

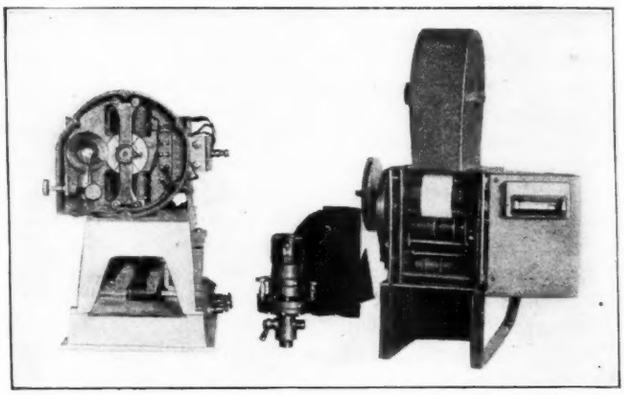


FIG. 11. VIEW OF PHOTOGRAPHIC AND TIME-SCALE APPARATUS

paratus. In Fig. 9 the indicator is shown lying on its side on a box; Fig. 10 gives a rear view of the same parts shown in Fig. 9, and Fig. 11 gives a larger view of the photographic and time-scale apparatus.

The only portion of the recorder that is in continuous operation during use is the time-recording mechanism. All other moving parts are controlled by a suitable foot switch which is depressed when a record is desired. This switch throws current to the lamp *F*, Fig. 5, excites the electromagnet, Fig. 3, and that which furnishes the field for the indicator, Fig. 2, and starts to feed the photographic paper from the magazine *V* of the recorder through the rollers and into the developing and fixing solutions. When the record has been taken, a knife cuts the paper and the exposed portion continues to feed through the solutions until it appears developed, fixed and washed.

The recording mechanism is arranged so that the exposure is made at any desired speed and the development at another, so as to insure the best obtainable contrast between light and shadow on the record.

Fig. 12 shows a record of pressure variations in a cylinder at 540 r.p.m., with retarded spark. The indications on the extreme lower edge of the record show the "in center" and "out center" positions of the piston. The sudden rapid rate of rise of the pressure shown on the main trace of the record comes slightly after the explosion "in center" position. The attainment of maximum pressure occurs when this trace crosses the horizontal line drawn through the undisturbed portions of the trace. In Fig. 12 this maximum pressure occurs $\frac{1}{100}$ second after the "in center" position and this corresponds to $\frac{1}{100} \times \frac{540}{60} \times 360$ deg. = 32.4 deg. of crankshaft motion after the "in center" position. Where the trace shows a maximum below its zero line, the pressure is falling most rapidly. This

occurs $\frac{15}{1,000}$ second after "in center" or $\frac{15}{1,000} \times \frac{540}{60} \times 360 = 48.6$ deg. of crankshaft motion after "in center." The pressure continues to fall, but less rapidly after this until the exhaust valve begins to open as shown by the trace beginning again to drop toward a second and rather flat maximum below its zero line. This begins $\frac{44}{1,000}$ second after explosion "in center," which corresponds to 142 deg. of crankshaft and the valve is wide open $\frac{5}{100}$ second after "in center," which corresponds to 162 deg. of crankshaft.

Fig. 13 shows the same engine running at approximately the same speed of revolution but with the spark more advanced. The rate of rise of the pressure is seen to be much more abrupt. Maximum pressure occurs 14.5 deg. of crankshaft after explosion "in center." Violent and rapid pressure variations occur during the portion of the cycle just after "in center," as shown by the broken character of the trace. This is the record of the "knock" due to an abnormally advanced spark. Fig. 14 is the record of one explosion between two "misfires" in the cylinder of a large four-cylinder engine provided with an automatic centrifugal governor for the spark advance. The engine was only lightly loaded and was making 1,824 r.p.m.

The induction stroke is seen halfway between the first misfire and the explosion. The ignition takes place only very slightly before explosion "in center," and the exhaust valve opening is very well marked.

This record was taken without the use of the auxiliary time record used to locate the position of the crankshaft. It is reproduced merely to show the character of a record taken with relatively great engine speeds. This record is not characteristic of an explosion of this engine since, owing to the misfire which preceded the explosion, the cylinder was "scavenged" for the particular explosion recorded. The ordinary, or non-scavenged, explosion of this engine at the same speed (a trace of which was obtained later on the same record) does not show so rapid a rise in pressure nor so quick an attainment of maximum pressure. A comparison of the records of scavenged and unscavenged explosions for this engine showed that in the former the maximum pressure was about 20 per cent greater than in the latter.

Figs. 15 and 16 show clearly the very marked difference in the character of the indicator diagram for the change from a very retarded spark (Fig. 15) to a very advanced spark (Fig. 16). Both records were obtained with a small four-cylinder Continental motor. Fig. 15, r.p.m. 700; maximum pressure 90 deg. after explosion in center. Fig. 16, r.p.m. 840; maximum pressure 20 deg. after explosion in center.

The great and long-sustained fall of pressure when the exhaust valve is opened after explosion with the retarded spark is well shown in Fig. 15. This should be compared with slight but well-marked indication of the exhaust-valve opening in the record of the explosion with advanced spark (Fig. 16). Figs. 12 to 16, inclusive, will serve to show the possibilities of an indicator of the type described, the deductions drawn being based on the study of many hundreds of original records which show details lost in the process of reproduction of the samples used to illustrate this article.

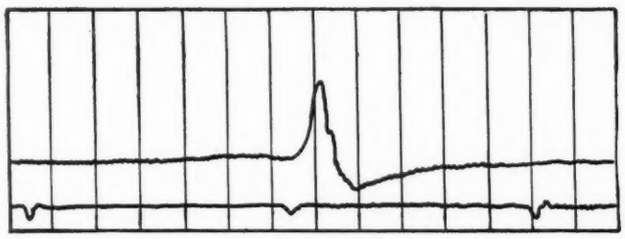


FIG. 12

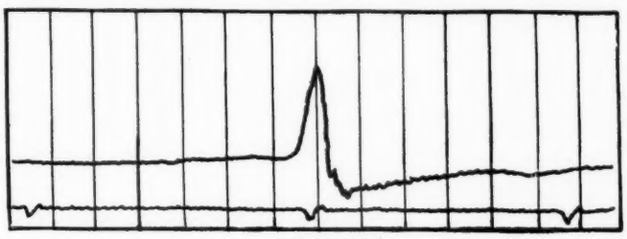


FIG. 13

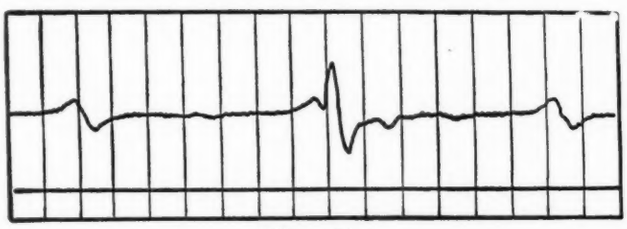


FIG. 14

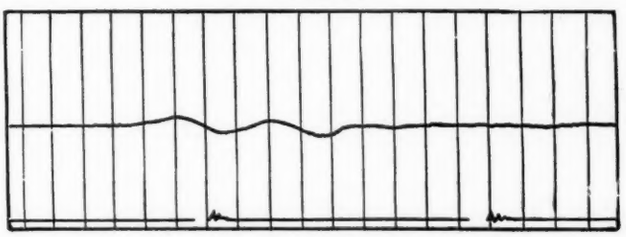


FIG. 15

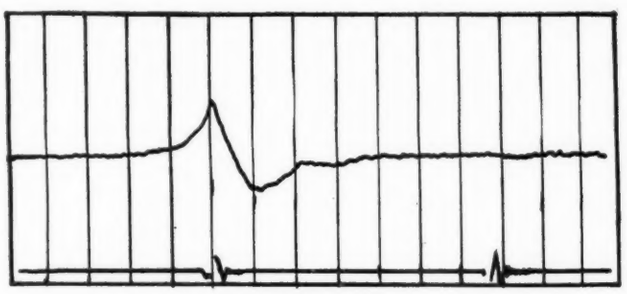


FIG. 16

FIGS. 12 TO 16. TYPICAL VELOCITY ACCELERATION DIAGRAMS

Note.—To illustrate the method of deriving one form of record from another let us assume that we possess a correct indicator diagram of the standard form and calculate the form that this diagram would assume if the co-ordinates, instead of being p and v were p and t; next, what the change of form of the diagram would be if the co-ordinates were changed to the rate of variation of p with the time $\frac{\delta p}{\delta t}$ and t. This is the form in which the diagram would be obtained with the par-

ticular indicator and recorder described in this article. The reverse steps to those which have just been outlined are the ones to be taken when it is desired to convert an experimental record with the co-ordinates $\frac{\delta p}{\delta t}$, t into the standard form of indicator diagram with the co-ordinates p, v.

Referring to the diagram, Fig. 6, curve *abcpdea* represents a typical indicator diagram in which the x co-ordinate represents the volume of cylinder and clearance volume for any position of the piston and the y co-ordinate represents the pressure which the gas exerts at any given volume. V_o is the clearance volume and V_m is the volume at the out center position of the piston. The dotted line *ab* represents the compression stroke. The full line *bcd* represents the expansion stroke to the point *d* at which the exhaust valve opens. The dotted line *ae* represents the scavenging stroke and the full line *ea* represents the induction stroke. The example chosen represents a cycle with a rather retarded spark.

To convert this diagram into its equivalent in which the time that has elapsed since the piston was at, say, explosion in center, is plotted along the axis of x instead of the volume as in Fig. 6, and in which, as before, the pressure is plotted along the axis of y, one has merely to divide the distance V_oV_m into equal time intervals instead of equal volume intervals as in Fig. 6. This may either be done accurately from measurements on the engine under test or with an accuracy sufficient for most purposes on the assumption that the piston executes simple harmonic motion when the crankshaft revolves with uniform speed. In this case the time at which the piston is in any position represented by p in Fig. 6 is given by the expression $V_t = \frac{V_m + V_o}{2} - \frac{V_m - V_o}{2} \cos\left(2\pi \frac{t}{T}\right)$, where T is the time in seconds of one rotation of the crankshaft and t is the time that has elapsed since the piston was at the explosion in center. In either case the pressure-time diagram has the form of the curve represented in Fig. 7.

The time rate of variation of the pressure $\left(\frac{\delta p}{\delta t}\right)$ is represented by the tangent of the angle of the slope of the curve of Fig. 6; that is, wherever the curve of Fig. 7 has a maximum or minimum value, $\frac{\delta p}{\delta t}$ is zero as shown in the curve of Fig. 8 at the points above *b*, *c*, etc.; wherever the curve of Fig. 7 has the greatest slope up, there is a positive maximum to the curve of Fig. 8, and where the slope is greatest downward there is a negative maximum to the curve of Fig. 8. One of the properties of this curve is that the total area of the negative loops must equal the total area of the positive loops for a complete cycle, say from $t = o$ to $t = T$, since any area between two given ordinates $t = t_1$ and $t = t_2$ is proportional to the difference of the pressures $(p_2 - p_1)$, which are represented by the curve of Fig. 6 at the two times.[1]

Since for a complete cycle the initial and final pressures are the same, the positive and negative areas of the curve of Fig. 8 must be equal. The recording instrument described in this article furnishes indicator diagrams of the type of the curve of Fig. 8, and the theoretical properties of the curve just discussed furnish a valuable check on the performance in practice of the indicator. It should be noted that this is a decided advantage of this form of diagram as no such severe test of the accuracy of the indicator exists for the case of the standard form of indicator giving a diagram of the form of the curve in Fig. 6.

It should be further noted by comparison of the curves of Figs. 6 and 8 that the position of the crankshaft when a valve opens or when the spark occurs may be much more accurately located from a diagram similar to curve 8 than it is from one similar to curve 6 (this will be apparent by comparing the various curves at the points *d*, *b* and *c*). In general, when a change of slope occurs in curve 6, there appears a much more marked feature in the curve 8, and this permits a much more accurate "timing" of the occurrence.

[1]This follows since the area is given by

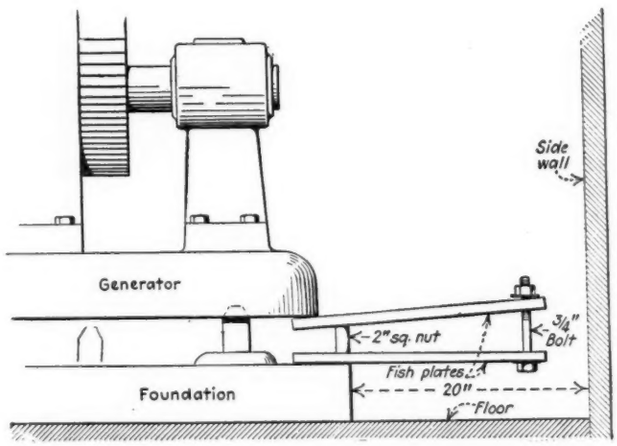
$$\int_{t=t_1}^{t=t_2} \frac{\delta p}{\delta t}\, dt = k\,(p_2 - p_1)$$

where k is a constant dependent on the scale of the drawing.

Handy Lifting Jack

BY O. B. CRITCHLOW

It was necessary to raise one side of a 125-kw. belted alternator in order to shim up the tightener rail, as the machine had settled. This machine was crowded into a corner as close as it was possible to get it, and



FISHPLATE LIFT JACK FOR RAISING ALTERNATOR

the end next to the side wall had to be raised. It might have been possible to make the lift with a small foot jack, but none was available and to use a lever was out of the question. The accompanying sketch shows the method employed by a machinist friend who was assisting the writer.

The materials used in this case were obtained from a near-by railroad scrap pile and consisted of two fishplates, a nut from a 2-in. bolt and a ¾-in. bolt with a long thread and a nut to correspond.

In a primary or common battery, the positive terminal of the battery is attached to the negative element and the negative terminal to the positive element. This should not cause confusion, for electricity must always flow from positive to negative, therefore from the positive to the negative terminal of the outside circuit, and from the positive to the negative element inside the battery.

Notes on Refrigeration

By ROLAND L. TULLIS

MANY refrigerating engineers fail to appreciate the value of a full charge of ammonia in a refrigeration or ice-making system, probably because they have been misinformed or have failed to study the theory of refrigeration. I have often seen amateur operating engineers who paid little or no attention to the amount of liquid in the receiver. If you questioned them they would tell you that the receiver was to catch the liquid in case of an emergency. They should be taught to realize that the proper amount of liquid in the receiver of a compression refrigeration system is as important as the proper amount of water in the gage glass of a boiler. Quite often the operators of small plants continue to open up on the expansion valves and purposely cut down on the amount of water flowing over the ammonia condensers in order to get the proper amount of suction and condenser pressure, when all the time the lack of pressure was indicative of an insufficient charge of ammonia. By continuing to open up on the expansion valves they were causing practically dry gas to be pumped through the coils with negligible refrigerating effect, at the same time losing the liquid seal in the receiver.

Leaking Compressor Valves

Leaking valves on the ammonia compressor are undoubtedly the cause of a great amount of lost power and consequent inefficiency in many refrigerating plants. On some types of compressors it is quite a problem for the engineer to ascertain whether the valves are functioning properly or not. With the modern types of double-acting horizontal compressors, which are always fitted with indicator connections, it is a comparatively

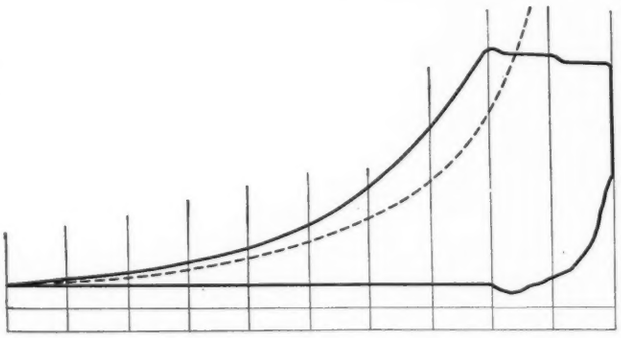


FIG. 1. DIAGRAM SHOWING STICKING SUCTION VALVE

simple matter for the engineer to apply his indicator, take a few cards and ascertain whether the valves are working properly. If the suction valves stick or the tension of the valve springs is too strong, the volumetric efficiency of the compressor will be reduced, owing to the fact that the piston will create a partial vacuum before the valves open, and because of the lower cylinder pressure the amount of gas drawn into the cylinder will be lessened. The indicator diagram will appear somewhat like Fig. 1, where the irregular suction line shows a sticking suction valve. On the other hand, if the discharge valves leak slippage will result, since on the compression stroke part of the charge will escape back into the suction line. If the discharge valves leak high-pressure gas will flow back into the cylinder and the efficiency of the compressor will be reduced. In Fig. 2 the compression curve starting above the isothermal and adiabatic lines reveals a leaky discharge valve.

There are many ammonia compressors of antique design but still in every-day operation, which are neither tapped nor fitted with connections for the use of an indicator; also many small single-acting compressors are not equipped for the use of an indicator. Here it becomes necessary for the engineer to devise some

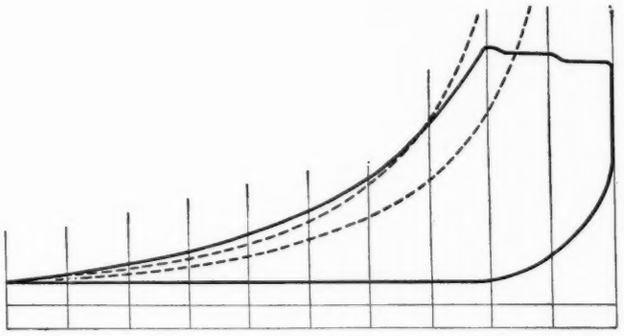


FIG. 2. COMPRESSOR WITH LEAKY DISCHARGE VALVE

other method to ascertain whether the valves are working properly. If it is impossible to use an indicator it is good practice to periodically remove, examine and test the valves for leakage.

Where the suction and discharge lines to the compressors are fitted with thermometers and where there are a number of machines operated in parallel or under the same conditions, it is often possible for the engineer to tell by the discharge and suction temperatures whether each machine is operating properly. Leaking suction valves on one machine will cause a higher suction temperature, since some compressed or high-temperature gas will escape back into the suction. The writer was once employed in a plant that contained two separate refrigerating units, both being connected to the same main suction and discharge line. They were vertical, twin-cylinder, single-acting compressors of 50-ton ratings. The refrigeration load was heavy, and both machines were run with the suction frosted back to the machines. Neither of the machines was equipped with indicator connections or thermometers, but it was a comparatively simple matter to tell whether the machine was doing its work. If the valves on one of the compressors started to leak, the frost would soon begin to disappear from its suction line, while the other would remain frosted, and vice versa. Of course the diappearance of the frost on one machine was indicative of leaky valves and consequent high suction temperature.

Flooded Cooling Coils

Many refrigeration engineers fail to appreciate the necessity of keeping the coils fully saturated with ammonia liquid. There is probably no greater cause of lack of efficiency in the refrigeration plant than that of failure to observe this rule.

To illustrate this point I will explain a simple experiment, which may help the engineer to better understand the necessity of plenty of liquid. Fig. 3 shows a test bottle partly filled with liquid anhydrous ammonia. The bottle is fitted with a rubber stopper and a glass tube which allows the escape of ammonia vapor. It will be observed that only that part of the bottle which is in direct contact with the liquid will become frosted. The upper part of the bottle, which is merely touched by the expanded or expanding gas, will not be covered with frost, which tends to show that the vapor liberated

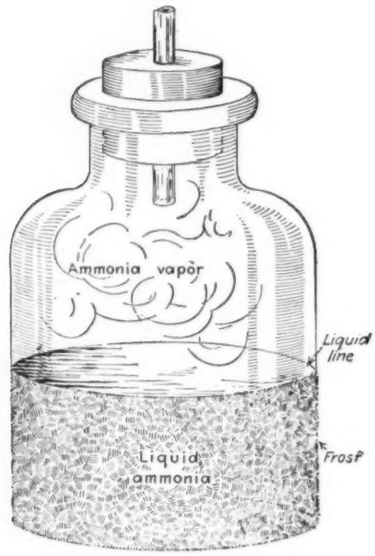


FIG. 3. REFRIGERATION EFFECT OF AMMONIA LIQUID AND VAPOR

by the ammonia and having the same temperature as the former has only a small cooling effect.

This simple test tends to show that only that portion of the surface of cooling coils which is continuously sprayed with or covered by the evaporating liquid will be available for the really efficient extraction of heat, and that dry ammonia gas pumped through a system will produce only an inconsiderable amount of refrigeration.

Water-Passage Corrosion in Gas-Engine Piston Rods

By William P. Flint

Serious and puzzling corrosion was at one time encountered in the piston rods of several large horizontal gas engines. These engines were double-acting and provided with piston cooling, the piston rod being drilled to afford entrance and exit for the piston cooling water. Fig. 1 shows a section cut through one of these rods. It was found that this corrosion was largely localized in the hotter part of the rod, on the intake side of the piston, and was nearly absent on an equally heated portion of the same rod on the outlet side of the piston.

The trouble was overcome by a slight change in the location of the passage connecting the bore of the rod and the cavity in the piston. This passage was originally drilled to lead diagonally downward into the bottom portion of the piston, as shown in Fig. 2, and it formed a gas trap that allowed the cooling water to pass freely, but retained in the bore of the rod any gas that the heating of the water set free.

The theory was advanced that in the case where this trouble occurred marsh gas was set free and acted corrosively on the steel rod. However this may be, the trouble was cured by drilling holes horizontally from the

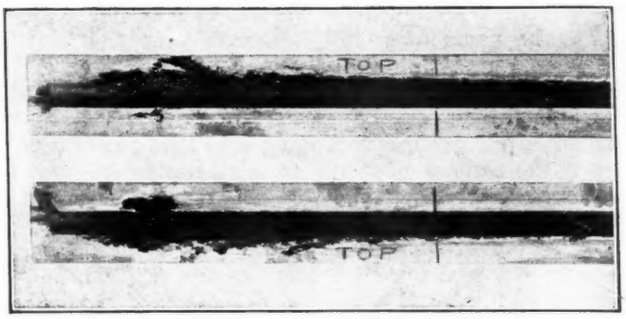


FIG. 1. CORROSION IN GAS-ENGINE PISTON ROD

top part of the bore of the rod into the piston cavity. These new holes eliminated the gas trap in the rod, but left a similar trap in the piston cavity.

No doubt the trouble would have shown itself in the pistons if they had been made of steel, but fortunately,

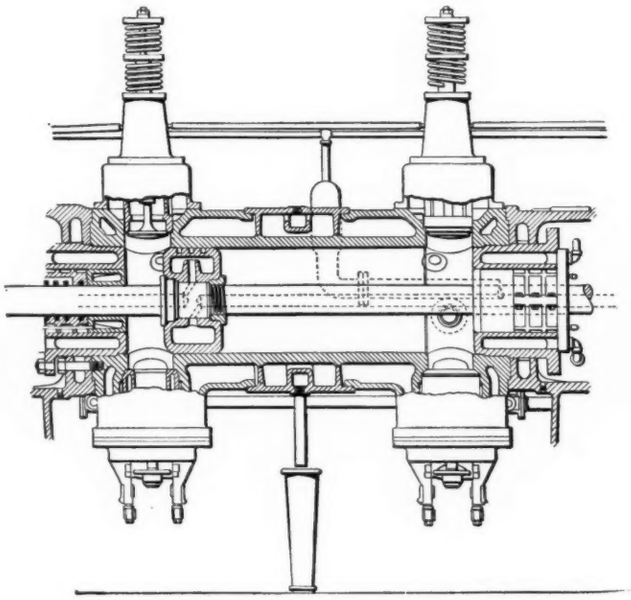


FIG. 2. PISTON-COOLING ARRANGEMENT

cast iron resists corrosion better than steel and the pistons were not attacked.

This trouble is to be distinguished from that arising from acid in the circulating water. Acid circulating water is more impartial in that it attacks the rod on both sides of the piston and may even attack the cast-iron piston.

Aciduous cooling water was the cause of much trouble in large gas engines when they were first introduced in this country. The cooling water was often taken from streams carrying much sulphurous and other acids. If any doubt exists, the cooling water should be tested.

All types of grates are not suitable for all types of fuel. A change in grates will frequently allow the use of cheaper fuel.

EDITORIALS

Reading Engineering Publications

IT IS unfortunate that many power-plant engineers do not read the publications devoted to this industry. It is by no means uncommon to hear engineers of no exceptional ability say that they already know everything the publications contain; others express the feeling that such matter as is published fails to fit in with the work which they are doing.

Of the first type little can be said, for when a man feels that he cannot profit by the experiences of fellow engineers, he is probably past saving. The second class, however, are suffering from a lack of vision. They are near-sighted, so to speak. While some particular job may be one where only the barest of engineering knowledge is required, such work offers little inducement to the ambitious man. It is almost a hard and fast rule that the pay accompanying any position is in proportion to the skill and knowledge required. If an engineer is at present in charge of a plant where, for example, no electrical equipment is used, it is injudicious for this engineer to assume that at no time in the future will he require information concerning the care and operation of electrical equipment. The next position that he seeks will probably call for a man who is familiar with electrical matters. The same reasoning applies to all the different phases of power engineering that are covered in the engineering publications.

Power engineering has taken such strides within the last twenty-five years that information on the steam engine is now but a small portion of the knowledge a plant engineer must possess to handle his work successfully. Along with this now go the operation of refrigerating systems, the care of electrical equipment, the supervision of oil-burning or stokered boiler rooms, and many other engineering practices.

The ambitious engineer does not restrict the horizon of his engineering knowledge to the limited experiences to be gained in his particular plant. Only by increasing his knowledge can he hope for a larger opportunity and an increased salary check.

Boiler Capacity

WHEN the "fire engine," as it was then called, was first built, it was furnished as a unit. The boiler and cylinder, piston and walking beam and condenser were all a part of the "engine."

The work that these engines were installed to do was usually being done by horses, so that it was natural to rate their capacity in horsepower.

When separate shops got to making boilers, they had to be furnished for engines the capacities of which were designated in horsepower, and naturally, the boilers came to be nominated in the same terms.

There was nothing so incongruous in this so long as engines required about the same amount of steam per horsepower. It is a boiler's business to furnish steam, and if it took a fairly definite amount of steam to make a horsepower, the steam which it furnished might as well be furnished in those units as in pounds or cubic feet.

And an attempt was made to settle it along these lines. At the Centennial Exposition in 1876 a committee of leading American experts appointed to test the boilers of the Exposition determined upon the equivalent of the ability to make thirty pounds of steam per hour having a gage pressure of seventy pounds from feed water of one hundred degrees as constituting the unit boiler horsepower.

But with the progress of the art there has been a growing sense of the incongruousness of the term. Large steam turbines are making a horsepower on some ten pounds of steam per hour. Small engine and turbine units under unfavorable conditions often take sixty pounds or more. The horsepower of the boiler may be entirely different from that of the engine, and purchasers have been known to feel that they had been cheated when they found that an engine or turbine that would require less than twenty pounds of steam per horsepower-hour had been fitted with a boiler rated at only two-thirds of the engine horsepower, although the boiler, running at only its rated capacity, would supply ample steam.

The function of a boiler is to supply steam; and yet the number of pounds of steam supplied is not a true measure of its capacity.

What kind of steam is it? High-pressure or low-, moist or superheated? Was it made from cold water, or water heated to the boiling temperature? More accurately, then, the function of a boiler is to transfer heat into the steam. Its ability to get heat into steam is the real measure of its capacity.

It has been proposed to use one thousand B.t.u. as the unit of evaporation. To make a pound of steam requires the putting into the fluid the heat content at the given pressure and quality or superheat, less the heat of the liquid at the feed-water temperature; that is, $H - h$. Multiply this by the pounds of water evaporated per hour and divide by 1,000, and you have the units of evaporation per hour. Divide by 970.4 instead of 1,000, and you have the equivalent evaporation from and at 212 degrees.

But what is the use of dividing by anything? $W(H - h)$ gives the number of heat units put into the steam per hour, the real measure of the boiler's capacity.

If an engineer had a 250-horsepower engine that would take 20 pounds of steam per horsepower-hour, he would need a boiler that would furnish 5,000 pounds of steam per hour. If the pressure and superheat were high and the feed-water temperature low, each pound would take more heat in the making than if the pressure were low, no superheat used and the feed temperature high. It is easy to find the values of H and h in a steam table for the given case, multiply their difference by 5,000 and find the B.t.u.'s that the boiler must transfer. For 150-pound 100-degree superheat, 184-degree feed water $H - h$ would be 1,100 and a 5,500,000-B.t.u.

boiler, or a boiler capable of imparting to the steam 5,500,000 B.t.u. per hour or doing 5,500 units of evaporation, would be needed.

A common method of rating boilers is by their heating surface, ten square feet of heating surface being equivalent to one horsepower. This means, upon the basis of thirty pounds of dry saturated steam from feed of 100 into steam of 70 pounds gage, 85 absolute, a transfer of 3,346 B.t.u. per square foot per hour, or about three pounds of steam per square foot, for the average case.

It is perfectly simple and a lot more sensible to designate the size of a boiler in square feet of heating surface than in horsepower. The surface has to be figured before the horsepower is known. Why not give the surface itself instead of dividing it by ten and calling the quotient "horsepower"?

When Safety Devices Become Hazards

THAT the safety-first movement has been productive of far-reaching results is evidenced by the numerous devices that have been developed for the protection of workmen and the laws enacted in various sections making the use of these protective devices mandatory.

In the electrical industry there has been practically from the beginning a tendency toward safety first, and within the last fifteen years this has been very marked, while laws have become more stringent regarding the protection of workmen from moving belts, gears, shafts, etc. No longer is it considered good practice to bring high-voltage circuits to the main switchboard. On the switchboards of modern alternating-current plants the highest voltage is generally that of the control circuits or exciter, which never exceeds two hundred and fifty volts, and these are installed so that live contacts are practically eliminated from the front of the board. In line with this movement switchboards have been developed with each panel mounted on trucks so that they can be removed from the board for inspection or adjustment of the equipment. Exposed current-carrying parts on switchboards are no longer considered good station practice.

Following out the safety-first development in power-plant electrical equipment came the introduction of this equipment into the industrial plants. At first, switches and fuses were installed in the open and the control device generally had a large number of exposed current-carrying parts. Gradually, this practice has been done away with until now the best practice dictates that the switch and fuses be installed in separate compartments so interlocked that access to the fuses can be had only when the switch is open and the fuses dead. By keeping the switch compartment locked, only authorized persons may have to do with live circuits.

Not infrequently, improper installation or lack of maintenance defeats the purpose of safety devices. If a safety switch is wired the reverse from what it should be, the fuses are alive when the switch is open, consequently it becomes a real hazard. Or if the interlocks get out of order and are removed instead of repaired, then the safety purpose has been defeated. This applies to all safety-first measures; they give protection only while maintained in proper working order. One of the most dangerous hazards is that due to improper grounding of the frames of electrical equipments. When first installed these ground connections are generally in good condition, but from lack of proper inspection and repair they frequently become of high resistance or open-circuited.

In such cases high-voltage machines are always exceedingly dangerous, since the attendants have become accustomed to believing that their frames are grounded and therefore safe to work around at all times. This is also true of grounding the secondary of step-down transformers; if these grounds are allowed to fail, then in case of breakdowns between primary and secondary windings the high voltage is present on the low-voltage circuit, and the hazard thus created is attested by numerous fatal accidents. The moral is that safety devices become most dangerous hazards unless they are maintained in condition to perform the functions for which they are designed.

The Flywheel Is Still with Us

ONE is prone to associate the flywheel with the old factory Corliss engine which drove by belt the machinery of a manufacturing establishment. The need of care in the operation of such a unit and the safety appliances necessary to safeguard the flywheel from disaster were generally appreciated. As the art has advanced in the last few years, the mind of the operator is turning to turbine units without flywheels, and the impression is gaining that the flywheel is not so important as it has been in the past. Occasionally, a flywheel is wrecked and we are brought face to face with the terrific amount of potential energy stored in one of these wheels and are forced to realize that the flywheel is still with us.

Where large turbine units are used with auxiliaries of the reciprocating type, there are a number of flywheels per unit, though of comparatively small size. It must be remembered that the energy stored in a wheel is not alone a function of the speed, but also depends upon the amount of metal that is in motion and the centrifugal force set up. Thus a machine with a comparatively small though heavy flywheel may have as much potential energy stored in it as a larger, lighter wheel.

Where, formerly, there was only the main flywheel to think of, with its accompanying safety device, there may be a number of flywheels serving one large generating unit, each one of them with its potentiality for disaster. Again, we must not neglect the flywheel effect of the rotor whether in the main unit or in the auxiliary machinery.

Failure of the flywheel on any one of the small units may cut a steam line or do damage that will cause a discontinuance of service to a much larger and more important load than formerly carried by one of the old time factory engines. The introduction of centrifugal auxiliaries is reducing the number of flywheels in use, but at that there are few plants that do not contain a flywheel of some character.

In a recent address at Philadelphia Secretary Hoover asked for suggestions as to how his department might better serve industry, mentioning in particular "studies along the commercial side of our power possibilities." Here is an opportunity for engineers to reach the Cabinet through one who can understand and talk their own language.

CORRESPONDENCE

Standard Name for Ratio of Thermal Efficiency

In Mr. Hoffman's discussion in *Power* for March 15, he reveals the necessity of a standard name for the ratio of the thermal efficiency to the Rankine cycle efficiency. Scarcely any two authorities use the same term. Various names such as "efficiency factor," "relative efficiency," "cylinder efficiency" and "Rankine cycle ratio" have been used by eminent engineers. The 1915 A.S.M.E. Power Test Code uses "Rankine cycle ratio," while the new code uses "engine efficiency." To the rising generation of engineers the use of so many terms to express the same thing is, to say the least, confusing.

It is to be hoped that a standard name will soon be adopted by all.

WALLACE H. MARTIN,
Professor of Heat Engineering.

Corvallis, Ore.

Why Producer Gas Is Not More Used

In the March 22 issue, J. M. W. Kitchen gives eight reasons why producer gas is not more used. There is no doubt that the increasing cost of fuel and the many advantages of the producer-gas plant should be given more consideration, particularly at this time when the cost of power enters so largely into the cost of production. Ten to fifteen years ago there were more gas-producer plants installed than at this time. The American manufacturer is more to blame for the "black eye" the gas producer has received in this country than the increased cost of producer-gas plants over steam or electric power. When properly designed and built, the gas producer and engine is one of the most economical prime movers known.

In the early days gas producers as manufactured in this country were copies of the foreign producers designed for the better grades of coal, which require less moisture and allow a greater quantity to be burned on a given grate area than is possible with the coal we have available in this country. Gas engines in America were built for illuminating and natural gas containing from 500 to 1,000 B.t.u. per cubic foot, and instead of keeping the foreign design of the engine, heavy, slow-speed, and built for the lean low-heat-value gas as made in a gas producer which requires high compression, many of the manufacturers simply increased the compression of the existing type of engine and wondered why they had so many failures.

Another big mistake was made in endeavoring to burn in the producer fuels for which it was not adapted. The average manufacturer gave too little thought to the proper design and construction of the apparatus to insure success. Producers are mostly all overrated, and in many instances too little attention was given to the vaporizers or economizers which are necessary with American coal of the lower grades to insure the proper amount of moisture or steam. Inadequate means were provided to regulate the amount of moisture to insure a uniform quality of gas. Whether it is a lack of knowledge on the part of the average engineer or a prejudice, gas-producer sales have not been developed in this country to the same extent as abroad. In England, France and Germany gas-producer installations are common. It is not unusual to see equipments as low as ten horsepower in operation, as well as many of very large size.

With the vast quantity of low-grade fuels available in this country and the high cost of coal, a gas producer is deserving of more consideration and there is no reason why producer plants should not be used more. The vast beds of peat and lignite existing in this country are not desirable fuels for burning under a boiler, but can be successfully utilized in a properly designed gas producer. In fact, there are, in the Southwest, several large installations that have been in successful operation for a number of years and are competing favorably with the highest-class steam plants. Probably one of the greatest stumbling blocks to the adoption of gas producers for burning bituminous coals and lignite has been the several freak-designed producers endeavoring to make clean gas without the use of tar extractors and proper washers. Nevertheless, there have been a number of successful plants built that are using standard bituminous up-draft gas producers of the water-seal type provided with ample wet scrubbers and mechanical tar extractors.

If the same engineering research work were given to the development of the gas producer and engine as has been given steam turbines, unaflow engines, oil engines, etc., the gas-producer outfit as a prime mover would occupy a more prominent position in this country and would be a means of greatly reducing the cost of power. Its field is broad, owing to its ability to operate on the lowest-grade anthracite coals, peat, lignite, charcoal, wood, tan bark, oil-shale rock and in fact, almost anything that will burn.

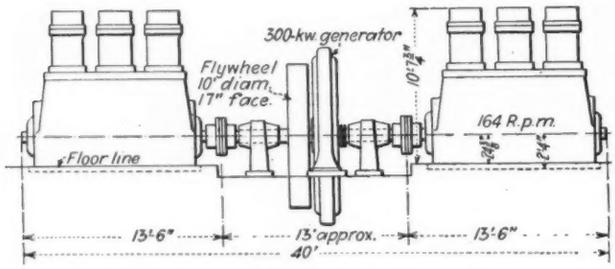
With this wide range of cheap fuels to draw on, the ever-increasing demand for power and the rapid decrease in the supply of the higher-grade fuels, it is high time that the American engineers familiarized themselves with the advantages as well as the disadvantages of a gas-producer installation.

H. P. HILL,
Ophuls, Hill & McCreery, Engineers.

New York City.

Aligning Engine Shafts

The firm I am with has purchased a double engine unit similar to the drawing shown. These engine shafts have flanged couplings and are connected to a short shaft carrying the flywheel and a generator. I would like to have some *Power* reader tell me the best way to line up these two engine shafts so that when the three parts of the shaft are bolted together the entire assembly will



DOUBLE-ENGINE-GENERATOR UNIT

be in alignment. The way the engines now stand, the crankshafts are already in the bearings, which are adjustable.

We are well equipped with a six-ton traveling crane, so can do all the lifting required. I would also like to have an estimate on the probable cost of aligning the engines and the time required. L. HARVEY.

Kansas City, Mo.

Boilermakers as Inspectors

A fact that somewhat surprised me when I became a boiler inspector was that there seemed to be but few inspectors who had actually served their time in the boiler shop. One would naturally suppose that boilermakers would go in for inspecting, and my conversation with a number of men of the craft indicates that a great many of them would do so were it not for the study involved. Boilermaking as a business is laborious work, and it is understandable that after a hard day in the shop a boilermaker does not feel inclined to sit down and dig into the matter of boiler construction and design.

I am acquainted with a man who is without doubt the last word as a good boilermaker and who has done work that inspectors claimed could not be done, and they have passed the completed job. This man, however, cannot figure the safe working pressure on a plain return-tubular boiler. He is anxious to become an inspector of boilers, but when mathematics comes up he reneges.

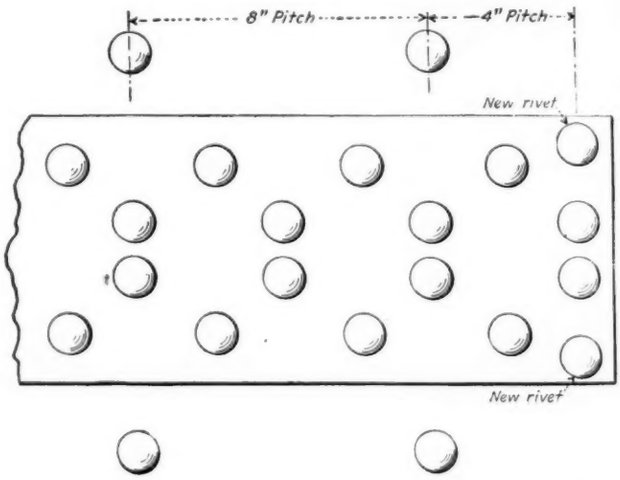
An incident happened some time ago that brought out how much better it would be if men working in kindred crafts would try to obtain at least a working knowledge of the business that runs in line with their own. I was sent to inspect a return-tubular boiler that was to be retubed, and found a very capable boilermaker on the job. All tubes had been removed, which gave an excellent chance for making a careful inspection of the shell. In looking the joints over, I noticed that the boilermaker had marked the two ends of the inside straps, and upon inquiry as to the reason, he stated that the strap corners had pulled away from the plate. He had taken this matter up with the owners and had received orders, based on his suggestion, to drive rivets in each corner to hold the strap against the plate. (See illustration.)

In this particular plant the steam pressure is kept at the blowing-off point and a reduction in the pressure of one pound would be highly objectionable to the owners.

A few passes of my slide rule and I saw that the application of the new rivets, as advocated by the boilermaker, would reduce the allowed pressure about nineteen pounds, practically putting the boilers out of service in this case. I tried to explain this in a practical manner to the boilermaker, but he would have none of it and frankly told me that I was taking the bread and butter out of his mouth.

I explained to him that, personally, I did not give a tinker what he did to the boiler, but that if I, as the representative of an insurance company, allowed the boiler to be ruined for the owner's use, I stood to get myself into serious trouble. In the end we laid our case before the manager, and after listening to the boilermaker's story, the manager asked me to explain just what harm these rivets would do.

My answer was about as follows: "One of the important factors in the design of a boiler joint is the pitch of the rivets. If we decrease the pitch of the rivets, all other conditions being the same, we decrease the efficiency of the joint as a whole. In this case we have a 72-in. return-tubular boiler, shell ½ in., tensile strength 55,000 lb., and a joint efficiency of 88 per cent, with an allowed pressure of 139 lb. If the rivet pitch is reduced as it would be in adding the extra rivets for the corners, the efficiency will be reduced to 78 per



RIVETING OF INSIDE STRAP, SHOWING POSITION OF PROPOSED NEW RIVETS

cent and the allowed pressure to about 120 lb., a drop of 19 lb., which would mean a new boiler or the plant put out of business." Fortunately, the owner could see the light, and as far as I was concerned the matter was ended.

The boilermaker would not admit that he was wrong. I tried to get him to allow me to show him the method of finding joint efficiency, but he declined to take any interest in the matter. Well, it ended with no rivets in the corners.

Here is a reason and a mighty good one, why boilermakers do not come into the inspection field.

South Quincy, Mass. A. D. PALMER.

Using Check Valves with Jet Condensers

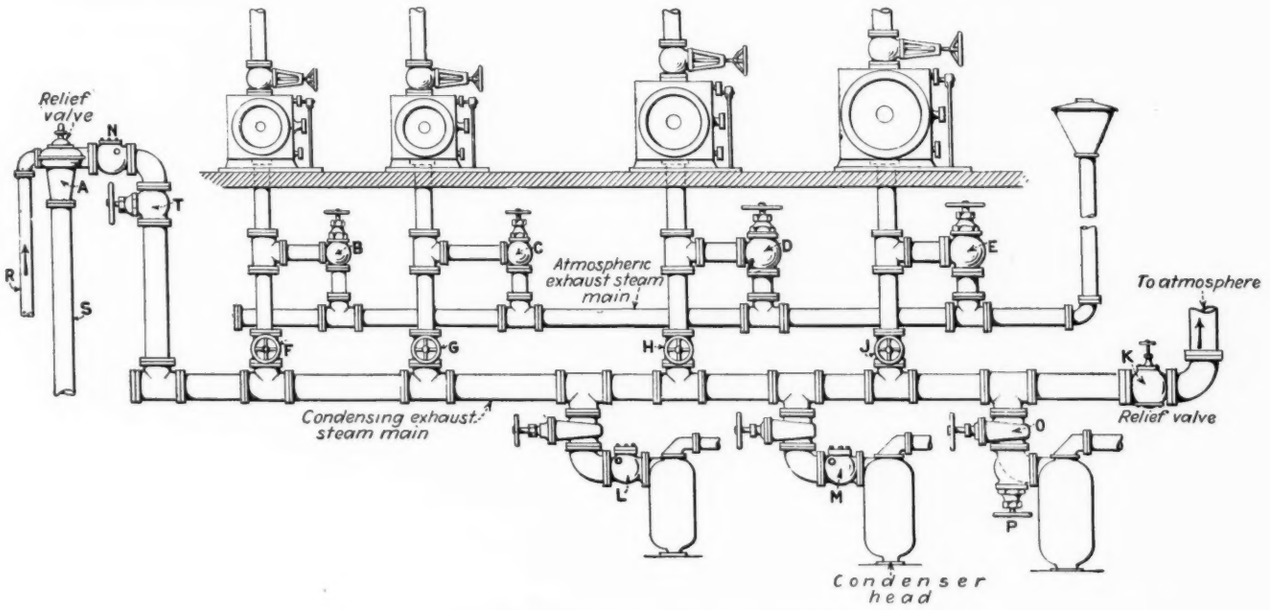
When a jet type of condenser is used for condensing purposes, there is a possibility of the condensing water getting into the engine cylinder when the receiver pressure drops below zero, especially on cross-compound engines, on account of a light load. This causes the low-pressure cylinder to act as an air pump and adds to the vacuum already in the exhaust pipe, and where the inlet-water valve is not throttled down, to admit only enough water to condense the steam, the vacuum may be so increased that water will flow into the engine cylinder and wreck the engine. This may occur when the condenser is carrying, say, 23 in. of vacuum and the load falls off. The receiver pressure will drop below zero, and the vacuum in the low-pressure cylinder is added to that in the condenser, which may run up to 25 or 26 in. This vacuum would cause more water to flow through the inlet-water valve than at 23 in. If the condenser should stop under such a condition, what is there to prevent the water getting into the engine cylinder until the vacuum is destroyed?

To overcome this menace in steam-plant operation, some engineers have suggested the use of the "hinge check" type of valves in the engine exhaust lines. This might be simple on small units and in plants having but one or two engines, but in large plants, with several engines and as many independent condensers, all connected to the one condensing exhaust-steam main, where should the check valve be placed, between the condensers and the exhaust or between the exhaust main and the engines? Probably it would be better to place one between each condenser and the exhaust main, as it is essential to keep the exhaust main free from water, as an accumulation of water might result in disastrous water hammer.

In some cases the size of check valve would be 18 in. or more and the space available would hardly permit the installation of standard-length check valves of this diameter. If the check valve were placed between the engine and the exhaust main, the size of each engine exhaust pipe would vary with the size of the engine, and there would be considerable difference in the cost of the valves.

The illustration shows such a piping system in a steam plant. I have added a barometric jet condenser *A* to the pipe line, thus showing two types of condensers. Four engines are shown; *B*, *C*, *D* and *E* are valves, the pipes connecting the exhaust pipes from the engines to the atmospheric-exhaust main, and *F*, *G*, *H* and *J* are valves between the engines and the condenser main. *K* is an atmospheric relief valve to release the steam in case the vacuum is lost.

The exhaust mains and the pipe connections from the engines to them and to the condenser chambers are on the same horizontal level. I have had each of these condensers stop at some time, but never all of them at the same time. The stopping of one when another was running only resulted in reducing the vacuum from about 6 in. before the stalled condenser was again started. With one condenser stopped and the others running and using no more water than was actually necessary to condense their proportionate share of the steam, they could handle much more water. They actually did take water out of the exhaust main which was coming in from a stopped flooded condenser, although at the time the engines were well loaded, but the water would not enter the engine cylinders until a vacuum was created in them.



PIPING AND VALVE ARRANGEMENT OF THE CONDENSING SYSTEM

The check valves are shown at *L*, *M* and *N*. *O* is an 18-in. stop valve and *P* an elbow which I have made into an angle valve. I believe that *L*, *M* and *N* is the right plan of connecting the check valves, but if a hinge type of valve was installed at *O*, an angle valve would have to be used at *P*.

Is there any reason why a combination angle check and stop valve could not be used instead of an angle valve and a horizontal check valve? The combination check and stop valve might be simply a loose valve disc riding on a guide spindle and the end of the valve stem. The stem, when in the open position, would allow the disc freedom of action to open or close, owing

to the action of the steam and vacuum, or when the water backs up against it. Then, when it is necessary to stop the condenser, the valve stem could be screwed tight against the disc, holding it shut as a stop valve.

There is an objection to a combination check and stop valve; if the valve disc or seat became scored and leaked, no repairs could be made on this condenser. If a check valve were placed at *O*, it would hold shut with the vacuum in the exhaust main acting against it, but it would not remain shut if the vacuum were lost in the exhaust main. In such a case a stop valve at *O* and an angle non-return check valve at *P*, whether combination stop and check or plain check valve, would be better. What do readers think of the two types of non-return valves?

With the barometric type of condenser, the condensing chamber is above the engine, and unless the check valve *N* is placed near the condensing chamber, a small amount of water forced back into the exhaust pipe might produce a siphoning effect to draw the water into the engine, both from the water inlet pipe *R* and the tail pipe *S*, if it was discharging below the level of the water in the well. It appears to me that in such a case a non-return valve in the tail pipe *S* would aid in preventing water getting back into the engine cylinder.

I know that many contend that water does not go back into an engine cylinder, but it has happened many times. With the barometric type of condenser a stop valve *T* may be closed before the throttle valve is closed tight, thus turning the exhaust to the atmosphere or, better still, if possible, shut off the water to the inlet.

R. A. CULTRA.

Cambridge, Mass.

Vacuum Pump Trouble on Heating System

I once came in contact with an interesting case of pump trouble in a small hotel heating plant. The problem baffled a number of operating engineers for a long time, but the cause of the trouble was easily remedied after it was discovered. The 110 rooms were heated by a vacuum system; that is, the return from each radiator was equipped with a small vacuum steam trap. A vacuum pump in the boiler room removed the condensation from the system, discharged it into the feed-water heater, whence it was pumped by the feed-pump back into the boiler.

The boiler room contained two horizontal return-tubular boilers, two small duplex feed pumps, an open-type feed-water heater and the vacuum pump. The manager of the institution explained that the system had been working unsatisfactorily for about eighteen months. The radiators kept filling with condensation, and there was a disagreeable pounding and thumping in the steam lines. A number of engineers had been employed, but they were unable to give satisfactory service. It seemed that they were unable to keep the vacuum pump running continuously. Whenever it stopped, the heating system would fill with condensation and refuse to function properly.

My first move was to interview the engineer an examine the cantankerous vacuum pump, as it was undoubtedly the cause of all the trouble. I could find no fault with it except that it balked occasionally and moved as if laboring under an overwhelming load.

Finally I glanced at the boiler steam gage and saw that it registered about 47 lb. Right then I got a "hunch" as to what was the matter with the vacuum pump. The engineer explained that he usually carried about 50 lb., sometimes less, as the city boiler inspector had set the safety valves at this pressure, maintaining that it was all that was necessary on a heating plant; regardless of the fact that they were high-pressure boilers capable of withstanding a safe working pressure of 100 pounds.

The whole trouble was caused by insufficient steam pressure to operate the type of pump, the steam piston of which was 8 in. in diameter with an area of 50.27 sq.in. and the pump end 16 in. in diameter, with an area of 201.06 sq.in. Owing to the fact that the pump was exhausting into the heating system under a back pressure of 6 lb. the mean effective pressure on the piston was never more than 45 lb. Multiplying the area of the piston by this m.e.p. equals 2,262 lb., total working effort of the piston. Occasionally the pump pulled a vacuum of 22 in. mercury, which is equal to 10.8 lb.; $10.8 \times 201.06 = 2{,}171$ lb. opposing the piston. Therefore it will be seen that both ends of the pump were practically balanced. With no allowances made for friction, one could hardly expect a pump to operate properly under these conditions.

The situation was explained to the boiler inspector, and he granted permission to increase the boiler pressure up to 80 lb., which ended the trouble.

Los Angeles, Cal. ROLAND L. TULLIS.

Oil in Ammonia Receivers

I have read with interest several articles regarding oil in ammonia receivers, and Mr. Lobban's comment in the March 29 issue, page 517, regarding manufacturers in the near future providing drain cocks at the lowest point of the receiver to draw off the oil.

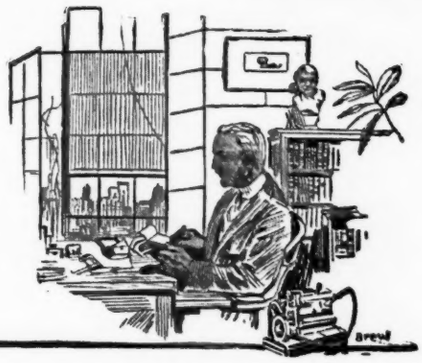
For several years I was connected with a company manufacturing refrigerating machinery, which made a standard horizontal type of receiver for all sizes of plants. These receivers were always fitted with a gage glass and an oil drain at one end and an outgoing liquid line at the other end, so arranged that the liquid could not be drawn lower than about 1½ in. of the bottom. The openings for the gage-glass connections on the smaller sizes of receivers were tapped in the circumference of the shell on the top and bottom, about 2 in. from the end. Short ¼-in. nipples and a tee were screwed in each, and gage-glass cocks were screwed into one side of the tee. An oil drain was screwed in the other side of the bottom tee. This method allowed a glass long enough to cover the diameter of the receiver, and any oil that came over would show in the bottom of the glass and could be drawn off through the drain valve, the ammonia always floating on top of the oil.

Objections are frequently made to having a gage glass on small receivers, but I think they are the ones that need them most, as small plants are usually in the hands of inexperienced refrigerating operators, and a visible means of determining the amount of the ammonia charge, as well as the accumulation of oil, goes a long ways toward giving them confidence in the operation of the equipment. The slight chance of glass breakage is more than offset by the satisfaction obtained by their presence.

W. H. FELLOWS.

Buttonwillow, Cal.

INQUIRIES OF GENERAL INTEREST



Diesel-Engine Output—What fuel consumption per kilowatt-hour can one expect from a Diesel engine at full load in ordinary operation? S. C. H.

A Diesel oil engine in fair operating condition will deliver a kilowatt-hour at the expense of 0.65 lb. of fuel oil.

Conversion of Specific Volume to Density—What is the weight per cubic foot of superheated steam at the pressure of 120 lb. per sq.in. absolute and 60 deg. of superheat? F. C.

According to Marks and Davis steam tables, the specific volume, or number of cubic feet per pound (weight), is 4.1 and the weight per cubic foot, or density, would be $1 \div 4.1 = 0.2439$ lb.

Cause of Back Firing—What is the cause of back firing in a gas engine? W. A.

This is usually caused by a slow burning of the gas mixture, the flame continuing until the inlet valve opens, whereupon the incoming charge is ignited. At times a highly heated part of the engine will ignite the gas as it flows into the cylinder, blowing back through the gas-mixing valve or carburetor. Also, a leaky inlet valve may cause back firing.

Variation from Test Gage—If a boiler steam gage registers 2 lb. higher than a test gage at 20 lb., will it register 2 or more pounds higher than the test gage at 100 pounds? E. M.

Because a gage is a certain amount ahead or behind a test gage at one point on the scale, it does not follow that it will be ahead or behind the test gage at other points of the scale, nor the amount of the variation.

Reducing Cylinder Condensation—What are the methods of reducing the losses from cylinder condensation? R. G.

Cylinder condensation is reduced by jacketing the cylinder; superheating the steam; compounding, or allowing the steam to expand in two or more cylinders, thus reducing the range of temperature in each, and quick running to reduce the time during which there is transfer of heat to and from the cylinder walls in the processes of cylinder condensation and re-evaporation.

Auxiliary Boiler For Oil-Burning Plant—In oil-burning plants where the boilers are allowed to cool down at intervals like week ends, what means is employed for warming the oil and starting the burners? D. E. C.

In most oil-burning plants where all main boilers are likely to be shut down at intervals, it is customary to employ a small coal- or wood-burning boiler as an auxiliary to furnish steam for starting the regular operations.

Whipping and Swaying of Engine Belt—What causes galloping of a double 15-in. driving belt of an 11 x 30-in. engine used for supplying power for machinery of a boiler shop? M. B. J.

Plunging or galloping of the belt would result from irregular speed of the engine and also from sudden fluctuation of load, such as operation of shears, punches and presses. If the galloping is in time with the strokes of the engine when driving a steady load, such as an electric generator or a steady friction load, the trouble would be due to insufficient weight of flywheel rim and would be reduced by operating the engine with lower pressure with later cutoff, and by equalizing the cutoff in opposite ends of the cylinder. To prevent whipping or swaying of the main belt from sudden variations of the load, it would be necessary to provide individual machines with heavier flywheels or have one flywheel or more on the shafting that would be sufficient for the purpose.

Greater Length of Pump Water Cylinder—Why are the cylinders of the water end of a steam pump made longer than the cylinder for the steam end? W. A. J.

Clearance in the ends of the water cylinder is advantageous in affording easy passages for water to and from the cylinder, and in addition the greater cylinder length provides latitude in length of the piston rod for adapting the stroke to the length of the steam cylinder without encroaching on desirable clearance in the ends of the water cylinder.

Exciter Capacity for Alternating-Current Generator—What exciter capacity would be required for a 300-kw. alternating-current generator? W. T. B.

The size of the exciter required for a 300-kw. alternator will depend upon the design of the machine; in particular, whether the machine is designed to deliver 300 kw. at 100 per cent factor or at some lower value, and also on the speed. If it is a low-speed machine, the exciter capacity required will be about 10 kw. If it is a high-speed machine, 6 kw. will probably be sufficient. It is always advisable, however, to apply to the manufacturer for advice in such a case, giving the complete name-plate data.

Heat Loss from Moisture in Coal—What is the heat loss from moisture in coal when its weight is equal to 20 per cent of the weight of dry coal and the heat value of the dry coal is 13,500 B.t.u. per pound? E. T. B.

The loss consists of the heat required to evaporate the water and superheat the vapor to the flue temperature at atmospheric pressure, and can be determined by the formula,

$$\textit{Loss in B.t.u. per lb. of dry coal} = W\,[212 - t + 970.4 + 0.47\,(T - 212)]$$

in which,

W = The weight of moisture per pound of dry coal;
t = Temperature of the coal as fired;
T = Temperature of the flue gases leaving the boiler;
0.47 = The mean specific heat of superheated steam.

Taking $W = 0.20$, assuming $t = 70$ deg. F. and $T = 500$ deg. F. and substituting the formula gives:

$$\textit{Loss per pound of dry coal} = 0.20\,[212 - 70 + 970.4 + 0.47\,(500 - 212)] = 249.5\ \textit{B.t.u.}$$

or nearly 2 per cent of the heat per pound of dry coal.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communication and for the inquiries to receive attention.—Editor.]

Explosion Hazards in Pulverized Coal*

By L. D. TRACEY†

THERE are two distinct methods of using pulverized coal which, for the sake of convenience, may be termed the direct and indirect.

In the direct method the coal, after it has been pulverized, is fed to a fan, by which it is forced in a "cloud" through pipe lines ranging from 8 to 16 in. in diameter. Branch lines convey the coal to the furnaces as may be needed; the surplus which has not been drawn from the main lines, returns near the point of beginning, where a separator removes the coal dust from the air and returns it to a storage bin to be blown through the line again. In other words, it is a continuous circulation of coal dust, the system being somewhat analogous to a gas line, where the fuel is drawn off as required. Secondary air lines, independent of the main coal-feed lines, provide the additional air at the burners necessary for proper combustion.

In the indirect method the coal is transported, either by means of compressed air or by screw conveyors, to bins at the furnaces. From these the pulverized coal is fed, generally by screw conveyors, to an air blast which carries the fuel into the burner.

As a rule the building, housing and crushing, drying and pulverizing machinery are situated apart from the industrial portion of the plant, and it is believed that this is most desirable from a safety point of view.

Adequate ventilation is absolutely necessary. It is unwise, however, to depend entirely on ventilation, for there are in a building many angles and corners that the air currents never reach and where the suspended dust will settle. A mixture of 0.032 oz. of coal dust per cubic foot of air has been sufficient to cause an explosion when brought into contact with a flame.

It is believed that it is practicable to install a vacuum-cleaner system in a coal-pulverizing plant by means of which all parts of the building in which dust is liable to settle may be reached. Dust should never be brushed or swept up without first being thoroughly wet down.

Clouds of fine coal dust are quite as dangerous as bodies of unconfined natural gas, if the dust is liberated in close proximity to an open flame or mass of hot metal.

Spontaneous Combustion Hazard

One of the most serious troubles with which the users of pulverized coal have had to contend, has been the number of fires that have occurred in the dried-coal and pulverized storage bins. It has been somewhat difficult to determine the exact cause of these fires, but there can be no doubt that spontaneous-combustion has played an important part in some of them.

It is perfectly obvious that coal in a fine state of division presents a much larger surface and brings a much larger quantity of reacting substances in contact with oxygen than when in solid mass.

Paradoxical as it may seem, coal dried at an abnormally high temperature will contain more moisture than when dried at a temperature of from 100 to 150 deg. F. The reason for this, as given by the Fuel Section of the Bureau of Mines, is that very hot coal carries with it, as it travels from the drier, a certain amount of vapor, due to the evaporation of moisture in the surrounding air with which the hot coal is brought into contact. This accompanies the coal to the bins and is condensed by the colder sides of the bins and conveyors.

The Bureau of Mines has investigated a number of fires in which, almost without warning, flames have burst from the coal-conveying lines. So far as could be ascertained, the lines were free from any obstruction, the fans were operating normally and the burners at the furnaces had been giving no trouble. It seems logical, therefore, to assume that the pulverized coal in the bins had been heated by spontaneous combustion to almost the ignition point, and when conveyed to the coal-transport line, enough additional oxygen was supplied by the air current induced by the fan to produce incandescence in the particles of coal, which in turn ignited the dust cloud passing through the line.

Whenever a plant has been shut down for a few days, before allowing pulverized coal to be delivered through transport lines to the place of consumption, an examination should be made to ascertain whether it has become heated to such a point that it might cause ignition when brought into contact with a current of air. This can be done by pushing iron rods into the interior of the stored coal and leaving them for a short time. When these are withdrawn, the temperature of the rod will indicate whether there is any fire in the bins.

Coking on Burners a Source of Trouble

Another source of trouble is the tendency of the coal to coke on the burners. Experience demonstrates that the burner becomes red-hot at the extreme end, owing to several reasons, such as too much coal for the amount of air or slowing down of the secondary blower from power fluctuations. The coal then begins to stick on the burner, and as the accumulation increases, the area of the burner is decreased, with the result that sometimes the burner actually becomes plugged, and as the secondary air has no other outlet, the current will tend to deflect into the coal-supply line, taking red-hot dust with it and eventualy causing a fire or explosion in the main distribution line. To avoid this, frequent inspections should be made of the burners, and if the least tendency to coke is shown, they should be immediately cleaned. Some of the steel mills employ a man whose sole duty is to inspect and clean burners.

Safety Rules for Pulverized-Coal Plants

I offer the following as a basis for regulations looking to the safer operation of pulverized-fuel plants.

Insist on cleanliness and freedom from accumulations of dust, both in the pulverizing plant and in the buildings in which the pulverized coal is used as a fuel.

Never brush or sweep up accumulations of dust on the floor or machinery without either wetting the dust or thoroughly mixing with an excess amount of fine incombustible material.

Adequately ventilate and light all coal-pulverizing plants and, when practicable, install some method of cleaning by vacuum system.

All open lights in and around the plant should be prohibited, and employees should not be allowed to smoke while in the building. This rule should also apply to superintendents and other officials who casually visit the plant.

The drier and the drier furnace should be separated by a fireproof partition from the pulverizing mills, conveying machinery and storage bins.

All pulverized-coal bins should be tightly closed and never opened if there is any possibility of ignition from an open flame. Bins should be equipped with automatic indicators to show the amount of coal in the bin.

Only men of known reliability should be entrusted with the direct operation of a drier. It may be more economical in the long run to pay a higher wage to a good man than a smaller wage to an unreliable man or boy.

Special care should be used not to overheat the coal in the drier, and recording pyrometers should be installed to enable the officials of the plant to check its operation.

The operation of the drier should never be stopped while it contains a charge of coal.

Fire in the drier furnace should never be started with paper, shavings or any light combustible material.

Fine coal at a temperature of over 150 deg. F. should never be stored in a bin, because of the liability of spontaneous-combustion, and for the same reason pulverized-coal

*Abstract of paper presented before the Mechanical Section of the Engineers' Society of Western Pennsylvania.

†Coal mining engineer, Pittsburgh Experimental Station of the United States Bureau of Mines.

storage bins should never be placed in close proximity to furnaces, boilers, steam pipes of flues.

Whenever a plant is to be shut down for a few days, all storage bins should, if possible, be emptied of coal. Where it is not possible to empty the bins, they should be thoroughly inspected for hot coal before the plant is again placed in operation.

In the direct system of using pulverized coal the primary air pressure should always be maintained at a much higher pressure than that of the secondary.

If a coal transport line becomes plugged up, the furnaces should be immediately cut off and the secondary air stopped.

After it has been cleaned, it is essential that no smoldering particles of coal be left in the line, and before starting the fan a thorough examination should be made.

Burners should be inspected frequently and any coke burned thereon removed.

Transport lines should be blown clean of coal when shutting down at the end of the day's work.

Never ignite the mixture of air and coal in the furnace by reaching in or opening the doors.

All conveyors and elevators should be tightly inclosed and never opened while running. Stop the machinery and allow the dust to settle before opening.

Never open a coal line, compressed-air tank or storage bin in the vicinity of a flame or open light.

Inclose all electric wires and cables in conduit as far as possible.

All switches should be placed outside the plant or in dustproof casings.

Non-sparking motors or motors in dustproof housings should be used.

Guard against sparks from static electricity in all rapidly moving machinery by having it thoroughly grounded.

All electric-light bulbs should be kept free from an accumulation of dust and all portable bulbs protected by heavy wire guards. Care should be taken to prevent arcing from loose socket connections or imperfectly insulated cords.

Stop all leaks in pulverized-coal transport lines or storage bins as quickly as you would a leak in a gas line.

Prohibit smoking, open lights or torches around the plant.

Educate the men to the dangers of pulverized-coal dust.

Pressure Distribution in Steam Turbines

In *Engineering*, Gerald Storey discusses the pressure distribution in steam turbines. He proceeds on the assumption that the total available heat drop is so divided between the stages as to keep the velocity ratio in each wheel constant. The velocity ratio he determines by the formula,

$$\frac{U}{c} = \sqrt{\frac{\triangle K}{2.65 \triangle B.t.u.}}$$

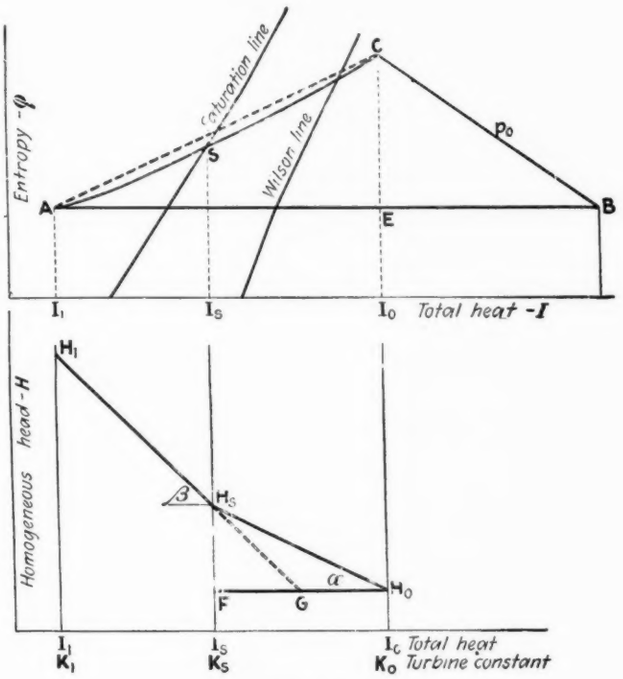
where

U = Velocity of blades in feet per second;
c = Steam velocity through the nozzles;
$\Delta B.t.u.$ = Heat drop in nozzles;
ΔK = $R^2 d^2 \times 10^9$ for each wheel;
R = Revolutions per minute;
d = Mean diameter in inches;
For the whole turbine B.t.u. = actual heat drop;
K = $E N L^2 d \times 10^9$.

He takes up a turbine with six one-row wheels as an example and obtains a table showing the volume, pressure drop and B.t.u. per stage, using a turbine efficinecy $n = 1$. In the actual turbine windage, blade friction, etc., will heat up the steam and increase the entropy and volume toward the exhaust end. Using an internal efficiency of 60 per cent, he shows that this reheating will increase the available B.t.u. by some 6.8 per cent, which, in the example used, will amount to 57.3 B.t.u. per stage instead of 53.7, as with an efficiency of $n = 1$.

*American Society of Mechanical Engineers, 1911 Transactions.

Checking this method by that given by F. E. Cardullo* as well as that of Professor Peabody, the author finds his values for pressures are about 10 per cent higher than obtained by the other investigators. He raises the point that by neither of the above-mentioned methods is it possible to obtain the volume values. Mr. Storey obtains an expression for the actual volumes by using the formula for the homogeneous head, $H = 144\ p\ V$; both the p and V for each stage may be found by assuming the difference between H and Ho to be equally distributed between the stages.



TURBINE HEAT DIAGRAM

It is reasonable to assume an equal distribution of H, since if H_1 and H_2 are the homogeneous heads at the beginning and end of a stage, the work done per stage

$$W = \frac{144\ V}{V - 1}(P_1 V_1 - P_2 V_2) = \frac{\gamma}{\gamma - 1} - (H_1 - H_2)$$

As W and γ are constant, it follows that $H_1 - H_2$ for all stages are equal. Employing the equation

$$log \frac{Pn}{P_{n+1}} = log\ X = \frac{C}{H}$$

where H is the head at the nozzle exit, the approximate value of C can be formed by integrating the equation

$$J\ B.t.u. = H \frac{dp}{p}$$

Calculating a table of pressures and volumes from this equation, the author finds the values obtained agree closely with those obtained by the Peabody and Cardullo methods. The author's method avoids the extensive use of entropy tables, but is not accurate at high degrees of superheat because of the change in specific heat, which is 1.3 down to the point where condensation begins and about 1.135 after this. A chart is given which shows the relation of H to K to be made up of two lines H_1H_n and H_nHo; the change in inclination is due to the fact that $\frac{\gamma}{\gamma - 1}$ for superheated steam is double that for the condensation portion. $\frac{\triangle H}{\triangle K}$ is correspondingly increased during the early part of expansion. The upper part of the figure is a Mollier

diagram, *AB* being the adiabatic drop and *AE* the work done in the turbine.

$\frac{AE}{AB}$ is, then, the efficiency ratio. *NC* is the point showing the final state of the steam. *ASC* is the condition curve which cuts the saturation line at *S*. The location of the point *S* is doubtful, but is at some point between the saturation and the Wilson lines. This chart enables the total heat at the saturation line to be determined.

The A. S. M. E. Spring Meeting

Further particulars of the Spring meeting of the American Society of Mechanical Engineers, which is to be held at the Congress Hotel, Chicago, May 23-26, have recently been announced.

Samuel Insull is to preside at the power session, which will be held on Thursday, May 26. W. L. Abbott will read a paper on the "Location and Distribution of Central Station Power in the Middle West" and will devote considerable attention to questions of interconnection of power systems. C. W. Place will give a paper on "Future Power Development in the Middle West" and will discuss the locations, amounts and possible development of water-power resources. In arranging this program the power division of the A. S. M. E. has been co-operating with the Chicago section of the American Institute of Electrical Engineers and the mechanical and electrical sections of the Western Society of Engineers.

Changes in the constitution and by-laws will be discussed at the business meeting on Monday and W. C. Marshall is to read a paper on "Graphics in Management" at the management session, Tuesday morning.

Several interesting trips have been arranged for each of four days—Tuesday, Wednesday, Thursday and Friday, May 24-27. Those that are of especial interest to *Power* readers are as follows:

Wednesday: Illinois Steel Co., South Works, South Chicago, plate mill, rail mill, bessemer converters and general steel mill equipment; Commonwealth Edison Co., modern turbine central station at Fisk Street; Pennsylvania Lines terminal, freight-handling plant, in connection with which there may be visited the neighboring warehouse of Marshall Field & Co. and the U. S. Terminal building; Crane Co., manufacture of valves and fittings in cast iron, malleable iron, steel and brass, the fabrication of pipe work.

Friday: Milwaukee Railway and Light Co.'s Lakeside plant, trip by rail to Milwaukee, boilers fired with powdered coal; Jos. T. Ryerson & Sons Co., warehouse of about a million square feet devoted to machinery and steel products

Waste Heat for Paper-Mill Ventilation

At the sixth annual meeting of the Technical Association of the Pulp and Paper Industry, held in April, 1921, in New York City, W. H. Howell, Jr., presented a paper describing the ventilating system installed in the Champlain Mills of the New York & Pennsylvania Co., by E. A. Briner, ventilation engineer, which presents some novel features. Mr. Howell says:

The usual practice has been to heat fresh air from outdoors by carrying it over steam coils, blowing it into the room and taking out the moisture from the driers, either by having openings in the roof or with exhaust fans. This system has been quite highly developed and gives satisfaction provided it is properly installed.

At the mill referred to this old system was in use, but as the production was increased about 100 per cent, it was found to be inadequate. We are now ventilating our machine room with two fans. One exhaust fan is used for pulling moist air out of the machine hood to the economizer, and a supply fan distributes the warm air to various points in the room. The hot outgoing air and the fresh cold air crisscross each other in the economizer without actual contact except through corrugated plates. The object of the corrugated plates is to enable the closest possible contact for transmission of heat from hot moist air to the cold fresh air, at the same time separating the moist air from the dry air. Both fans are belt-connected to a single 20-hp. constant-speed electric motor.

In average winter weather (34 deg. above zero) the economizer is able to raise the outdoor air to 107 deg. F. for distribution in the machine room in quantity sufficient for all ventilating purposes and without the use of any steam whatsoever. This result is accomplished solely by utilizing the waste vapor going out of the machine hood and still leaving a large quantity of vapor available for other heating purposes.

It was found that 107 deg. was too warm for the comfort of the operators, and a certain amount of moist air was consequently allowed to escape into the atmosphere without passing through the economizer, so as to bring the air temperature supplied to the room down to 98 or 100 degrees.

So far as we know, this is the first practical use of the idea on a large scale for heating and ventilating a machine room without the use of steam from the boiler plant. By its means first-class ventilation conditions are assured in a place that formerly presented a very difficult and expensive operating condition. Of course the intention is also to use such waste heat in some cases to assist drying operations in summer.

Pacific Coast Leads in Power Consumption per Capita

In a recent rate hearing before the Railroad Commission of California John A. Britton, vice-president and general manager of the Pacific Gas and Electric Co., presented charts showing to what extent hydro-electric power has developed the resources of the Western States, in which water power abounds.

The Pacific Coast States, according to the charts, produced an income to the power companies of $11.17 per capita as against the $8.24 of Atlantic States, $6.82 of the New England States and $5.52 of the Central States. The consumption of kilowatt-hours per capita in 1919 was 673, as against that of the Atlantic States of 363, of the Central States of 271 and of the New England States of 254. The Pacific Coast States were selling energy to their consumers, said Mr. Britton, at a lower cost than any others in the Union. He declared that the average rate in 1919 to the Pacific Coast consumers was $0.016¢ per kilowatt-hour, Central States $0.0204, Atlantic States $0.0228, and New England States $0.0293. He also said that the Pacific Coast consumers used 6.75 times as much hydro-electric energy per capita as all the other states in the Union.

These figures are quoted from a statement issued by the California Railroad Commission.

Mr. Britton also presented figures to show what the Pacific Gas and Electric Co. proposes to do in the way of construction in the next ten years. From 1910 to 1920 the number of consumers on the company's system increased from 73,500 to 266,132, and based on this previous record and the situation today, Mr. Britton estimated that by 1930 the peak demand on the company's system would total 570,000 hp. To meet this expected increase in demand the company plans to expend within the next ten years a total of $161,000,000 in its power, water, gas and railway departments. Of this total about $138,500,000 will be required for the development, delivery and distribution of power from the Pit River, where construction is now under way on a chain of large hydro-electric generating stations. This power will be transmitted to San Francisco over a 220,000-volt transmission line, the highest voltage thus far proposed.

Early Piston Speeds.—In arguing that the loss of power consequent upon increasing the velocity of the piston is less in the high-pressure than in the low-pressure engine Dr. Ernst Alban, in a book upon "The High-Pressure Steam Engine," published in 1847, says: "This is corroborated by the well-known fact that the piston of a high-speed engine may be driven at *great velocity* (250 to 300 ft. per minute) without entailing the loss which always ensues when the velocity of the low-pressure engine exceeds about 200 ft. per minute.

New Publications

THE BUSINESS LIBRARY. By Louise B. Krause. Published by the *Journal of Electricity and Western Industry*, San Francisco, Cal., 1921. Paper; 5 x 7 in.; 122 pages; illustrated.

The purpose of the book, now in its second and somewhat revised edition, is to put at the business man's disposal, as briefly as possible, full information on the organization and use of a business library. Librarians who expect to undertake business-library work should also find it useful. The author is the librarian of H. M. Byllesby & Co., Chicago, and has been enabled by her ten years' experience in similar work to prepare a composite study of many business libraries rather than to describe one. The book covers specifically: The organization of the library; the filing of periodicals, Government documents, catalogs, photographs and lantern slides; methods of classification and cataloging; the selection of mechanical equipment and of the best reference books, with information on where they may be obtained. A chapter is included on "The Essential Qualifications of the Business Librarian." A number of references to articles and books on the subject is also given.

ANALYSIS OF SULPHUR IN COAL

The United States Bureau of Mines has issued recently Technical Paper No. 254 entitled "The Analysis of Sulphur Forms in Coal," by Alfred R. Powell, organic chemist. The paper is a further description of the method of determining the various forms of sulphur in coal as originally outlined by the author while working with Prof. S. W. Parr at the University of Illinois. This method is shown to be accurate in the analysis of coal from widely different fields, instead of only from Illinois as was the original plan. Copies of the paper may be obtained from the Director of the Bureau of Mines, Washington, D. C.

WATER-GAS APPARATUS

Technical Paper 246, "Water-Gas Apparatus and the Use of Central District Coal as Generator Fuel," by William W. Odell, has recently been issued by the United States Buerau of Mines and may be obtained from the Director of the Bureau at Washington. The paper covers preliminary studies made while considering the possibility of substituting Indiana and Illinois coal for coke in water-gas generator sets.

Personals

Prof. E. F. Nichols, a physicist of note and formerly president of Dartmouth College, has been appointed president of the Massachusetts Institute of Technology.

Howard M. Raymond has been appointed acting president of the Armour Institute of Technology to fill temporarily the vacancy created by the death of Dr. F. W. Gunsaulus.

C. A. Hill has completed a 1½ years' survey of proposed hydro-electric and irrigation projects in Arizona and California for a New York syndicate and has returned to New York.

H. B. MacFarland has resigned his position as engineer of tests for the Atchison, Topeka & Santa Fe Railway Co., and is now practising as a consulting engineer in Chicago, Ill.

M. R. Buchanan has taken a position as chief engineer for the Spears & Miller Ice Co., El Paso, Tex. He has resigned as manager of the Silver City Power Co. but will continue to act as consulting engineer for that company.

S. H. Merrick, who for the last five years has been with the Conveyor Corporation of America, is now associated with the Reordway Company, 140 South Dearborn St., Chicago, district agents for Detrick arches and steam-jet ash conveyors.

R. L. Watts has left the St. Paul & Tacoma Lumber Co. and has gone into business with Harold H. Lewis as power-plant equipment engineer, with offices in the L. C. Smith Building, Seattle, Wash.

C. F. Herington, who has been connected for the last five years with the Bonnot Co. as mechanical engineer and district sales manager in Chicago, resigned May 1st to accept a position as vice-president of the Holbeck Engineering Co., Cleveland, Ohio.

Major Harry B. Joyce, formerly with the Construction Division of the Army, has resigned as a member of the firm of Johnson & Benham, Inc., consulting engineers, to take charge of the engineering work of the Centrifugal Fan Co., Newark, N. J., which is engaged in the manufacture and installation of fans, blowers, ventilating apparatus and systems.

Society Affairs

Akron Section, A. S. M. E., will hold a meeting May 13 at which E. S. Carman, president of the society, will be the speaker.

Baltimore Section, A. S. M. E. will hold a joint meeting May 5 with the Engineers' Club of Baltimore, at which Frank B. Gilbreth, of Montclair, N. J., will speak.

Cleveland Section, A. S. M. E., will meet May 3 to hear an address on the "Relation of the Engineer to the Management of Corporations," by Gen. C. C. Jamieson, of G. D. Goethalls & Co.

Rochester Section, A. S. M. E., will hold a joint dinner for the professional engineers of Rochester at the Powers Hotel on May 5. The speaker will be Calvert Townley, vice-president of the Federated American Engineering Societies.

The American Society of Mechanical Engineers has announced a Great Lakes regional meeting to be held June 13 and 14, in Cleveland. Local sections and engineering clubs in the following cities have been invited to participate: Akron, Buffalo, Chicago, Cincinnati, Columbus, Detroit, Erie, Rochester, Toledo, Indianapolis, Ontario, Pittsburgh and Dayton.

Miscellaneous News

The Campaign for Reduction of Accidents, both industrial and public, has resulted in the formation of the Society of Safety Engineers of California. Walter A. Chowen, manager of the California Inspection Rating Bureau, was elected president and J. C. Chandler, California Casualty Indemnity Exchange, secretary-treasurer. Thirty-four safety engineers, representing casualty insurance companies and industrial concerns active in accident-prevention work, are charter members.

The Finnish Government is showing an increasing interest in water-power development and is making efforts to promote its exploitation. There is said to be about 3,000,000 hp. of water power in the country, and of this only 170,000 hp. is being developed. Work has already been started on a plant at the Imatra Falls which will contain eight turbines, each of a capacity of 7,100 cu.ft. per second. The financial side of this project, however, is not settled yet, the Finnish government evidently relying on private enterprise to furnish the necessary capital. As Finnish industry is incapable of supplying the necessary machinery for projects of this kind, it is thought that quite a number of foreign orders may be placed within the next few years.

Business Items

Griggs & Myers, consulting engineers and power-plant specialists, have moved to 347 Fifth Ave., New York City.

Crecelius & Philips is the name under which Lawrence P. Crecelius and Victor B. Philips have associated as consulting, construction and operating engineers, with offices at 1302 Hanna Building, Cleveland, Ohio.

The Hooven, Owens, Rentschler Co., Hamilton, O., has announced the appointment of three new agencies: H. F. Kircher & Co., Peoria, Ill.; E. J. MacMillan, 1005 Bates St., Grand Rapids, Mich.; and Ross L. Fryer, Albee Building, Washington, D. C., for the District of Columbia.

The L. J. Wing Manufacturing Co. is moving from its New York location to a new building recently completed for it in Newark, N. J., which will house its offices and factory and will give 50 per cent more space than it has at present. The sales office is to remain at 9th Ave. and 13th St., New York City.

The Hayward Co., 50 Church St., New York City, has announced that H. M. Davison has rejoined the company after two years as general sales manager of the Ohio Locomotive Crane Co. Mr. Davison served with the Hayward Co. from 1903 to 1919 and is now to have the general management of sales.

The Sanford Riley Stoker Co., Worcester, Mass., has announced that the sales management for Riley underfeed stokers and Murphy furnaces has been concentrated under one head. William Pestell is to be sales manager, with headquarters at 1226 Woolworth Building, New York City, and W. L. Bigelow and C. Lincoln Smith will be district managers, respectively, of the Pittsburgh and Cincinnati territories.

Trade Catalogs

The Fuller Engineering Co., Allentown, Pa., is distributing a new 8 x 10½ in., 36-page catalog, No. 700, which describes in detail its pulverized-coal equipment for locomotives.

The Wellman-Seaver-Morgan Co., Cleveland, Ohio, is distributing an 8-page folder containing descriptions and diagrams that show very clearly the construction of the W. S. M. balanced plunger hydraulic valve.

The National Tube Co., Frick Bldg., Pittsburgh, Pa., has prepared an 8½ x 11-in. 44-page booklet, "National Selling Aids." which is full of helpful suggestions to jobbers as to means of advertising "National" pipe.

The Voorhees Rubber Manufacturing Co., 20 Bostwick Ave., Jersey City, N. J., is sending out a circular and booklet which describe its line of belting, water hose, steam hose, air-drill hose, and "RUB-STEEL" valve.

The Direct Separator Co., Inc., Syracuse, N. Y., is sending out a new 6 x 9-in. 40-page catalog, No. 521, which goes into a thorough discussion of steam separators, oil separators, combination separators and exhaust heads.

The Superheater Co., 30 Church St., New York City, is distributing a new bulletin, No. T-7, "Superheaters for Stationary Power Plants," the object of which is to explain the advantages of superheated steam in as non-technical a way as possible.

Engberg's Electric and Mechanical Works, St. Joseph, Mich., has put out a new 8 x 11-in. 36-page catalog, No. 301, which presents in an attractive manner the features of the Engberg steam engine. This engine is of the vertical, stationary, single-cylinder, inclosed type and is built in various sizes from 1 to 100 hp.

The Vacuum Oil Co's New York branch has prepared an attractive 9 x 11-in., 16-page booklet, "The Horizontal Steam Turbine," which explains the construction and operation of turbines with regard to problems of lubrication. The Rochester branch has prepared a similar booklet, "Stationary Steam Engines," discussing the reciprocating engine. Both books go into the subject thoroughly.

Frederick Stokers, one of those catalogs that are handy to have in one's desk or data file, has just been issued by the Frederick Engineering Co., of Frederick, Md. It is in the form of a loose-leaf binder with 56 pages already bound in. These describe in detail the Frederick underfeed stoker, and show with line engravings its installation in different types of boilers. There are also 10 pages of diagrams showing the variation of temperature in the furnace and different passes, and of the CO_2 with different rates of firing for determining boiler and furnace efficiency, etc. It is sent free upon application to those interested.

The DeLaval Steam Turbine Co., Trenton, N. J., is distributing a valuable book entitled "Ten Years' Progress in Water Works Pumps," containing 100 pages, 8 x 11 in. It is properly described as "A manual for water works officials and engineers" and represents a large amount of compilation and writing, but is distributed free of charge. The book includes a discussion of the economy of different types of pumping units and a description of notable installations of turbine-driven centrifugal pumps in municipal plants. The testing of steam turbines and centrifugal pumps and the measurement of head and discharge are explained, and considerable data are given on the measurement of water by venturi tubes, pitot tubes, orifices and weirs.

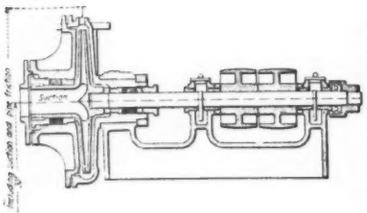
Condensed-Clipping Index of Equipment

Patented Aug. 20, 1918

Pump, Wilfley Centrifugal

Wilfley Co., Ltd., Salisbury House, London Wall, E. C. 2, London (*Engineering*, London)

"Power," March 29, 1921

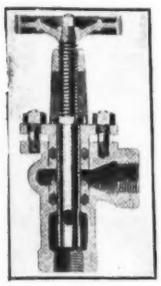


The chief feature of the pump is in the impeller, which embodies a suction passage that separates the suction and delivery side and prevents leakage from one to the other. The hollow impeller end is carried in a packed gland of which the friction is very small. One pump under test with a 12-in. impeller gave a maximum delivery of 111½ gal. per min., lifted to 125 ft. at 1,500 r.p.m., and 193 gal. to 53 ft. at 1,320 r.p.m.

Valves, Yarway Junior Seatless

Yarnall-Waring Company, Philadelphia, Pa.

"Power," 1921



This valve has been developed for use for water-column blow-down valve, for soot-blower service and for turbine and superheater drips. The valve stem is made solid except at the bottom end, which is hollowed out and has an opening to the outlet through a hole in the stem. This eliminates the necessity of a valve disc and seat. The stem is made tight by molded fiber packing rings that automatically tighten when closing the valve. This valve is made in the angle and straightway types.

Mikamet Plastic and Twist Packing

Goodsell Specialty Co., 153 N. La Salle St., Chicago, Ill.

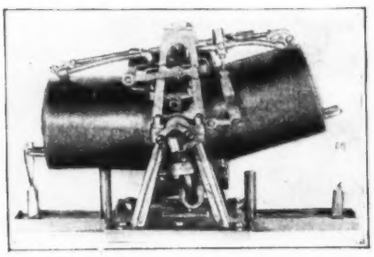
"Power," 1921

This new packing is composed of granulated babbitt metal and mica flour for the lubricating material, which is so thoroughly impregnated throughout the mass that it is not eliminated by acids or such chemicals as may be handled by pumping machinery. This packing is put up in plastic and twist forms, is adapted for all degrees of pressure, cold or hot, up to 600 deg. and is designed to meet any pressures generated in steam or hydraulics. The plastic type is for use on centrifugal machinery, pump plungers, expansion joints, etc. The twist type is for stuffing boxes, valve stems, etc.

Trap, Redmond Tilting Steam

John Redmond, 377 East 158th St., New York City.

"Power," March 1, 1921

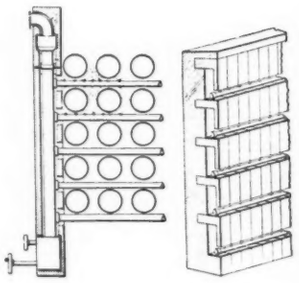


This trap is automatic in action and will handle high-temperature water, delivering it directly to the boiler or other receptacle regardless of the pressure or temperature in the vessel. The machine receives and discharges at the same time. It can be employed to handle oil or other liquids by compressed air instead of steam. It also serves as a water meter, as by attaching a counter to the machine it will register the cubic feet of water passing through it as it cannot reverse from one position to another until the receiving tank is filled. The machine is made in both horizontal and vertical form. Suitable valves controlled by the tilting of the trap regulate the flow of steam and water.

Blower, McNeill Soot

Wm. N. McNeill, 1328 Smeed Street, Logansport, Ind.

"Power," Feb. 15, 1921

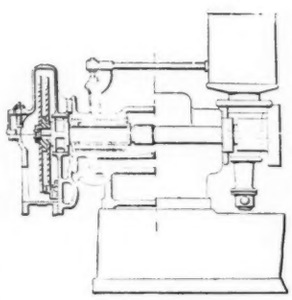


In this blower the tube-blowing elements are swung by means of gears between the tubes, thus bringing the high velocity steam or air jets into contact with the tube surface. As there will be corners that would not be reached in the travel of the blower elements across the tube surface, nozzles are placed in the end of the elements which reach these corners. The nozzles and the pipe are protected from the hot furnace gases by special tiles, which form a recess in the furnace wall, in which the blowers rest except at such times as they are in the actual service of blowing the tubes.

Turbine Set, New Geared

The Steam Motors Co., Springfield, Mass.

"Power," Feb. 1, 1921

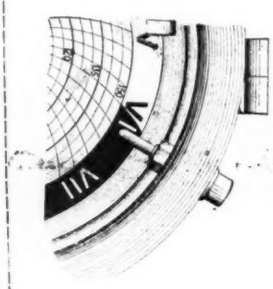


This turbine is a geared unit designed to eliminate the trouble arising from distortion of the alignment of the bearings due to high and varying temperature existing at the turbine end, and the uncertain behavior of metals when subjected to varying temperatures. The turbine wheel is mounted on the gear pinion shaft; the driver gear, which is mounted on the shaft driving the pump or turbine, as the case may be, is in a housing with the pinion gear. This housing is horizontally divided along the center line of the pinion and gear shaft. An oil reservoir in the bottom of the housing supplies the lubricant for the force-feed system.

Recorder, Time Punch

Schaeffer & Budenberger Manufacturing Co., Brooklyn, N. Y.

"Power" 1921.

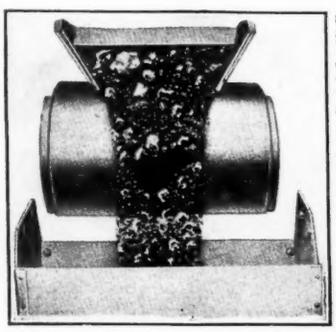


The Columbia recording thermometers have an attachment in the shape of a time-punch device record by which the operator in charge of temperature control registers the hour and minute of his visit by means of the time punch. Every time a temperature reading is taken, he presses a button on the lower right side of the recording thermometer, and simultaneously a hole is punched in the margin of the revolving chart. This time punch will also be applied to Columbia recording gages and to tachometers.

Coal Scale, Improved Automatic Boiler Room

Richardson Scale Co., Passaic, N. J.

Power, March 29, 1921.



The improvement in this scale is found mainly in the adoption of a conveyor feed of heavy rubber belting with canvas interwoven, which is easily replaced. A simple takeup is provided. The belt starts when the weigh hopper is ready to receive coal and stops when it has taken in the standard charge of 200 lb. Less than ½ hp. is required to drive the feed belt. The drive may be by either motor or belt. The speed is reduced by two sets of spur gears. Corrosion is eliminated, as only copper rivets are used where coal comes in contact with the walls, and the skirt plates, hopper walls and door plates are made of fibrous, acidproof, abrasion-resisting material.

Clip, paste on 3 x 5-in. cards and file as desired

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		60c. per ft.
Common, 2½-in.		50-10%

	Air		
	First Grade	Second Grade	Third Grade
¼-in. per ft.	$0.40	$0.25	$0.19

Steam—Discounts from List

First grade	40%	Second grade 10-10-5%	Third grade 60%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	60-10-5%	Best grade	40-10%
Standard	50-5%		

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
45%	30-10-5%	30-5%

RAWHIDE LACING { For cut, best grade, 40–10%, 2nd grade, 45–10%. For laces in sides, best, 53c per sq. ft.; 2nd, 51c. Semi-tanned: cut, 30–10%; sides, 55c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	1.00
Asbestos for high-pressure steam	2.00
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	.70
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.50
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.50
Asbestos wick, ¼- and 1-lb. balls	.85

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure ..... List +5%

For low-pressure heating and return lines { 4-ply ..... 50% off; 3-ply ..... 52½% off; 2-ply ..... 54% off

PORTLAND CEMENT—New York, $2.90 without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles .ees, and plates, all $3.33 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York		
	Current	Cleveland	Chicago
White	10.00@13.00	12.50	14.25
Colored mixed	7.00@11.00	9.00	12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.65	$0.66	$0.68
5 gal. cans	.68*	.81	.93

*Charge of $2.25 for two cans.

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current Dry and In Oil	1 Yr. Ago Dry and In Oil
	Dry	In Oil	Dry	In Oil		
100-lb. keg	13.00	14.50	15.00	16.50	13.00	15.00
25- and 50-lb. kegs	13.25	14.75	15.25	16.75	13.25	15.25
12½-lb. keg	13.50	15.00	15.50	17.00	13.50	15.50
1-lb. cans	16.00	17.50	17.50	18.50	16.00	17.00
5-lb. cans	18.00	19.50	19.50	19.50	18.00	18.00

500 lb. lots less 10% discount; 2000 lb. lots less 10–2½%.

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ¼ and smaller	50%	60%	45%
Tinned	45%	60%	30%

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York	$4.65	Chicago	$4.88	Pittsburgh	$3.40

Boiler rivets, same sizes:

New York	$4.75	Chicago	$4.98	Pittsburgh	$3.50

REFRACTORIES—Prices in carlots:

Chrome brick, eastern Shipping points	net ton	70@ 80
Chrome cement, 40@45% Cr_2O_3	net ton	40@ 45
Chrome cement, 40@45% Cr_2O_3 in sacks	net ton	44@ 49
Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky	per 1000	55@ 60
Clay brick, 2d quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky	per 1000	45@ 50
Magnesite brick: 9-in. straight	net ton	80@ 90
Magnesite brick: 9-in. arches, wedges and keys	net ton	88@ 98
Magnesite brick: Soaps and splits	net ton	112@ 128
Silica brick: Chicago district	per 1000	55@ 60
Silica brick: Birmingham, Ala	per 1000	45@ 51
Silica brick: Mt. Union, Pa	per 1000	45@ 60
Magnesite cement: Eastern shipping point, in bags	net ton	59@ 64
Magnesite cement: Eastern shipping point, in bags	net ton	55@ 60

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	70.00	40.00	35.00
Commercial	30.00	15.50	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$4.73	$4.63	$4.25
Flats, square and hexagons, per 100 lb. base	5.23	4.63	4.75

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	50%
Boiler lugs	Net list
Boiler stay bolts	60%
Boiler patch bolts	Net list
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	Net list
Pressed steel boiler hangers	Net list

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card:

BUTT WELD

Steel			Iron		
Inches	Black	Galv.	Inches	Black	Galv.
¼ to 3	57½	44	⅛ to 1¼	24½ to 25½	8½ to 09½

LAP WELD

2	50½	38	2	20½ to 21	6½ to 07
2½ to 6	53½	41	2½ to 6	22½ to 23	9½ to 10
7 to 12	50½	37	7 to 12	19½ to 20	6½ to 07
13 and 14	41				
15	38½				

BUTT WELD, EXTRA STRONG, PLAIN ENDS

¼ to 1¼	55½	43	⅛ to 1¼	24½ to 25½	9½ to 10½
2 to 3	56½	44			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	48½	37	2	21½ to 22½	8½ to 09
2½ to 4	51½	40	2½ to 4	23½ to 24	11½ to 12
4½ to 6	50½	39	4½ to 6	22½ to 23	10½ to 11
7 to 8	46½	33	7 to 8	14½ to 15	2½ to 03
9 to 12	41½	28	9 to 12	9½ to 10	5½ to+2

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.27
1¼	.....	.....	.26
1½	.....	.....	.24
1¾	$0.2200	$0.3255	.26
2	.2100	.2834	.25
2¼	.2400	.3176	.29
2½	.2910	.3814	.36
2¾	.3298	.4323	.39
3	.3686	.4781	.43
3¼	.4365	.5663	.51
3½	.4032	.5728	.55
4	.5124	.70	.72

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 60.00(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	10%	5%
Coils to 1,000 ft.	20%	15%
1,000 ft. and over	30%	20%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.43
12 to 50	.41
50 to 125 (bbl.)	.38
125 (bbl.) or over	.35

CONDUIT, Price per 1000 ft.; ELBOWS AND COUPLINGS, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black 2,500 to 5,000 Lbs.	Conduit Galvanized 2,500 to 5,000 Lbs.	Elbows Black 2,500 to 5,000 Lbs.	Elbows Galvanized 2,500 to 5,000 Lbs.	Couplings Black 2,500 to 5,000 Lbs.	Couplings Galvanized 2,500 to 5,000 Lbs.
¼	74 30	79.40	17.75	18.90	6.55	6.95
⅜	98.20	105.10	23.35	24.85	9.35	9.95
½	145.20	155.40	34.55	36.80	12.15	12.90
¾	196.40	210.20	44.25	46.95	16.75	17.75
1	234.85	251.35	59.00	62.65	20.65	21.90
1¼	316.00	338.20	108.25	114.85	27.55	29.20
1½	499.60	534.70	177.10	187.90	39.35	41.75
2	653.30	699.20	472.30	501.10	59.05	62.65
2½	813.30	886.50	1,043.05	1,106.65	78.70	83.50
3	995.35	1,050.75	1,205.40	1,278.90	98.40	104.40

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
½	250	$0.05½
⅝	250	.06
¾	250	.09
⅞	200	.12
1	200	.15
1¼	150	.18
1½	100	.25
1¾	100	.33
2	Odd lengths	.40
	Odd lengths	55

1000 ft. and over.... 55%
Coils..... 45%
Less coils, 35%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.43
D. P. M. L.	.21	T. P. to D. P. S. B.	.26
T. P. M. L.	.33	T. P. S. B.	.38
D. P. S. B.	.23	T. P. D. B.	.64

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.50	$1.30	$1.68
T. P. M. L.	.70	1.70	2.40
D. P. S. B.	.63	1.60	.....
T. P. S. B.	1.15	2.40	.....
D. P. D. B.	1.10	3.00	.....
T. P. D. B.	1.90	5.40	.....
T. P. to D. P. D. B.	1.30	3.80	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$15 40
No. 16 cotton twisted	18.00
No. 18 cotton parallel	18.40
No. 16 cotton parallel	21.50
No. 18 cotton reinforced heavy	25.00
No. 16 cotton reinforced heavy	29.00
No. 18 cotton reinforced light	23.50
No. 16 cotton reinforced light	27.50
No. 18 cotton Canvasite cord	18.50
No. 16 cotton Canvasite cord	25.75

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.25	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	035	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 15%; 1-5th to standard pak age, 28%; tandard package, 45%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	Net list
Unbroken carton but less than std. pkg.	10%
Std. pkg.	18%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	18%
Discount With Contract—Fuses:	
Broken cartons	5%
Unbroken cartons but less than standard package	15%
Standard package	23%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	23%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$4.75C
0-30 ampere, less than standard package	5.25C

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.25	24
25	.40	.45	100	150	1.55	1.70	24
40	.40	.45	100	200	2.10	2.30	24
50	.40	.45	100	300	3.15	3.40	24
60	.45	.50	100				12
				500	4.60	4.90	12
				750	6.50	6.90	8
				1,000	7.50	7.95	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.28
Composition 2-piece attachment plug	.36
Swivel attachment plug	.20
Current taps	.45

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.25	$ 9.00	$11.45	$18.00
12	8.50	11.50	13.75	22.75
10	15.00	17.65	18.00	31 65
8	18.00	21.55	24.00	43 10
6	.....	.....	36.50	...
4	.....	.....	48.50	.....
2	.....	.....	67.25	.....
1	.....	.....	90.00	.....
0	.....	.....	106.50	.....
00	.....	.....	131.00	.....
000	.....	.....	158.00	.....
0000	.....	.....	182.00	.....

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap Key Each	Keyless Each	Pull Each	⅛ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	+50%
1-5th to standard package	+20%
Standard package	—15%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	42c. lb.
No. 18 B. & S. regular 1-lb. coils	43c. lb

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 48c. lb., 100 lb. lots	44c. lb.
Rubber tape, ¾ in., less 100 lb. 50c. lb., 100 lb. lots	45c. lb.
Wire solder, less 100 lb. 40c. lb., 100 lb. lots	36c. lb.
Soldering paste, 2 oz. cans	$1.50 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	15%
$10 to $25 list value	net list
$25 to $50 list value	5%
$50 to $200 list value	20%
$200 list value or over	25%

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	April 19 1921	April 26 1921
Pocahontas,	Columbus	$3.25	$3.35
Clearfield,	Boston	2.35	1.85@2.50
Somerset,	Boston	3.05	2.25@3.35
Pittsburgh,	Pittsburgh	2.25	2.00@2.50
Kanawha,	Columbus	2.00	2.25
Hocking,	Columbus	2.15	2.20
Pittsburgh No. 8	Cleveland	2.25	2.15@2.30
Franklin, Ill.,	Chicago	3.40	3.25@3.50
Central, Ill.,	Chicago	2.50	2.50@3.00
Ind. 4th vein,	Chicago	2.75	2.50@3.00
Standard,	St. Louis	1.95	1.75@1.85
West Ky.,	Louisville	2.25	1.85@2.60
Big Seam,	Birmingham	3.05	2.70@3.25
S. E. Ky.,	Louisville	2.75	2.65@2.85

DIESEL FUEL OIL

New York—On April 26, Port Arthur light oil, 23@25 deg. Baumé, 5⅜c. per gal. 30@35 deg., 6¼c. per gal. f.o.b. Bayonne, N. J.

Chicago — April 23, for 24@28 deg. Baumé, 70@75c. per bbl.; 32@34 deg., 2½@3c. per gal. In tank cars, f.o.b. Oklahoma refinery, or freight adjusted.

St. Louis—April 23, prices f.o.b. cars, tank lots: 24@26 deg. Baumé, 55c. per bbl.; 26@28 deg., 70c.; 28@30 deg., 80c.; 32@34 deg., 2¼c. per gal.

Baltimore—On April 23, f.o.b. refinery; in tank-car lots: 24+ deg. Baumé, 6¼c.; 26@28 deg., 6½c.; 30@34 deg., 7⅜c.; 14+ deg., $1.95 per bbl.; 16@20 deg., $1.85 per bbl.

Pittsburgh—On April 23, f.o.b. refinery; Pennsylvania, 36@40 deg., 7c. per gal.; Oklahoma, 24@30 deg., 65c.; gas oil, 32@34 deg. 2¼c. per gal., 36@38 deg., 2¾c. 38@40 deg. 3c.

Philadelphia—On April 12; 26@28 deg. Baumé, Oklahoma, 85c. per bbl.; 30x34 deg., Oklahoma (group 3) 3c. per gal.; 16@20 deg., Seaboard, 5c. per gal.

Cincinnati — April 23, for 22@28 deg. Baumé, 7.34c. per gal.

Cleveland — April 23, for 22@28 deg. Baumé, 5½c. per gal.

New Construction

PROPOSED WORK

Vt., Waterbury — The State Hospital Comn., Montpeller, plans to build a receiving ward building, refrigeration plant, laundry and dining building also rebuild kitchen at the State Hospital for the Insane here. About $250,000. Architect not yet selected.

Mass., Boston—The City Parks and Recreation Bd., 33 Beacon St., received bids for 1 story, 192 x 290 and 80 x 112 ft. range of Greenhouse and boiler house at Franklin Park, from P. Vincenzi Co., 147 Orleans St., East Boston, $30,583; John Bowen Co., 184 Dudley St., $34,467; J. J. Bowes Co., $35,000.

N. Y., Albany — The Trustees of Pub. Buildings Capitol, are having plans prepared for an 11 story office building. About $4,000,000.

N. Y., Hempstead, L. I.—The Rivoli Theater Corp., c/o Reilley & Hall, Archts. and Engrs., 405 Lexington Ave., New York City, plans to build a 12 story, 80 x 200 ft. theater and store building including a steam heating system, here. About $250,000.

N. Y., New York — (Brooklyn Boro) Shape, Bready & Peterkin, Archts. and Engrs., 220 West 42d St., New York City, plans to build a 6 story, 200 x 300 ft. apartment house including a steam heating system on Shore Rd. and 79th St., here. About $600,000. Owner's name withheld.

N. Y., New York — (Manhattan Boro) The New York Edison Co., Irving Pl. and 15th St., is having plans prepared for a substation on 40th St. and 1st Ave. About $200,000. W. Whitehill, 12 Elm St., Archt. and Engr.

N. Y., Utica—The Utica Motor Car Co., Kent St., will soon award the contract for a 2 story, 50 x 250 ft. garage and service station. About $250,000. Linn Kinne, Mayro Bldg., Archt.

N. J., Newark—The city will receive bids about May 23 for a market. About $1,300,000. F. Grad, 245 Springfield Ave, Archt. and Engr.

N. J., Newark — The Sub-Marine Boat Corp., Newark Bay Shipyard, P. O. Box 456, is in the market for 1 gasolene driven air compressor complete with engine and receiver. Capacity should be sufficient to operate 5 air guns which require about 250 cu.ft. receivers.

N. J., Newark—The Y. M. H. A. plans to build a Y. M. H. A. building on High and Kinney Sts About $500,000. Architect not yet selected.

N. J., Short Hills—The Bd. Educ., Millburn Twp., will soon receive bids for a 2 story, 60 x 150 ft. high school including a steam heating system on Old Short Hills Rd., here. About $250,000. Guilbert & Betelli, 2 Lombardy St., Newark, Archts. and Engrs.

Pa., Norristown — The McCarter Iron Wks. Inc., is in the market for one 65 hp., 220 volt, d.c. 600 to 800 r.p.m. motor and a 35 to 40 hp., 220 volt, d.c. 600 to 800 r.p.m. motor.

Pa., Philadelphia—F. D. and M. E. Felt are having plans prepared for a 2 story, 101 x 135 ft. moving picture theater on 19th and Chestnut Sts. About $1,000,000. W. Steele, 16th and Arch Sts., Archt.

D. C., Washington — Hunt & Hunt, Archts. and Engrs., 28 East 21st St., New York City, are having plans prepared for a 7 story, 40 x 100 x 140 ft. apartment house including a steam heating system on 16th St. About $400,000. Owner's name withheld.

W. Va., Cameron—The Cameron Mining & Development Co. is in the market for power plant equipment, etc. G. E. Myers, Pres. and Mgr.

W. Va., Charleston — The Beni Kedem Shrines, Masonic Temple, Virginia and Hall Sts., is having preliminary plans prepared for a 2 story shrine temple including a steam heating system on Kanawha St. About $500,000. Rapp & Rapp, 190 State St., Chicago, Ill., Archts.

W. Va., New Martinsville—The Universal Concrete Products Co. Inc. is in the market for two 5 hp., one 7½ hp. and one 10 hp. motors, 220 volts, 3 phase. H. Eschenbrenner, Secy. and Treas.

N. C., Raleigh — The North Carolina State College plans to enlarge the heating plant. About $50,000. W. C. Riddick, Pres.

S. C., Charleston—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to install an air compressor here.

Ga., Atlanta—The Tsi Chi Trust Association plans to build a 14 story, 100 x 150 ft. office building including a steam heating plant on Forrest Ave. and Cordlandt St. About $700,000. W. J. J. Chase, Atlanta Trust Co. Bldg., Archt.

Fla., Ft. Pierce—The St. Lucie Ice Co. plans to build a 2 story addition to its plant and install a 50 ton unit to be electrically driven. R. Whyte, Pres.

Fla., West Palm Beach — The South Florida Hotel Co., Box 306, had plans prepared for a 7 story, 95 x 170 ft. hotel including a laundry, refrigerating plant, etc., on Banyan St. About $500,000. H. G. Fink, Miami, Archt.

Ala., Dothan—The city plans to build a 1,500 hp. hydro-electric power plant. A bond issue amounting to $750,000 will be sold for the purpose of financing the project.

La., Cedar Grove—The city is having plans prepared for a new waterworks system including 3 wells, pumping equipment, etc. About $150,000. E. T. Archer & Co., Kansas City, Mo., Engr.

Tenn., Martin—The city will receive bids about June 1 for improving and enlarging the light and power plant. F. L. Wilcox, Chemical Bldg., St. Louis, Mo., Engr. Noted March 1.

Tenn., Memphis—The city voted $2,000,000 bonds to build two 5,000,000 gal. reservoirs with piping and five 1,000,000 gal. reservoirs with well and equipment, and plans to convert present plant into an electric plant, etc. Address F. G. Proutt, Chn. of the Memphis Artesian Water Co.

O., Canton—The G. D. Harter Bank, 113 Market St., plans to build a 4 story bank and office building including a steam heating system on Market St. About $300,000. Walker & Weeks, 1900 Euclid Ave., Cleveland, Archts.

O., Cleveland—I. Margolin (Builder), 1924 East 105th St., has purchased a site at 3629 Euclid Ave., and plans to build a 5 story, 75 x 200 ft. apartment hotel including a steam heating system on same. About $300,000.

Mich., Battle Creek—The Bd. Educ. will receive bids until May 9 for a 3 story, 78 x 200 ft. and 75 x 188 ft. vocational school. About $500,000. J. D. Chubb, 109 North Dearborn St., Chicago, Archt. Noted Dec. 14.

Mich., Detroit — The Ford Motor Co., Highland Park, had plans prepared for a 10 mi. 23,000 voltage, 6 wire transmission line from Springwells to Highland Park, to include steel towers at the street crossings.

Mich., Detroit — The Supt. of Lighthouses, Post Office Bldg., will receive bids until May 5 for 2 electric motor air compressors and 5,500 ft. submarine electric cable.

Ill., Chicago—The Melrose Hotel Co., c/c John A. Nyden, Archt., 190 North State St., is having plans prepared for a 6 story, 90 x 125 ft. apartment hotel including a steam heating system on Melrose St. and Lake Shore Drive. About $300,000.

Ill., Chicago—Smith & Dubin, c/o Dubin & Eisenberg, Archts., 14 West Washington St., will soon award the contract for a 3 story, 150 x 160 ft. apartment house including a steam heating system on Birchwood Ave. and Sheriden Rd. About $300,000.

Wis., Chippewa Falls — The Chippewa Falls Woolen Mills, 901 Prarie St., is in the market for power machinery for its proposed 2 story, 62 x 130 ft. woolen mill.

Wis., Madison—Frank Bros., 607 University Ave., are in the market for ice making and refrigeration machinery.

Wis., Milwaukee—The Sewerage Comn. received bids for furnishing and building 4 water tube boilers, mechanical stokers, superheaters, settings, forced and induced draft equipment, economizers and appurtenances, from,

Proposal No. 1. Industrial Heating & Eng. Co., 143 Oneida St., $233,400, alternate A. $240,000. (Different type of boiler) $114,200, alternate A. $130,000; Wenzel & Henoch, 498 27th St., $276,199, alternate A. $277,795; B. $296,153; C. $285,600; W. A. Pope, 26 North Jefferson Ave., Chicago, $278,700, alternate A. $262,687.

Proposal No. 2. Heine Safety Boiler Co., 38 South Dearborn St., Chicago, $99,390, alternate A. $115,390; Babcock & Wilcox Co., 85 Liberty St., New York City, $112,531, alternate A. $126,671 and $134,951, alternate $149,512; D. Connelly Boiler Co., Ivanhoe Rd. and the New York & St. Louis R.R., Cleveland, O., $117,000.

Proposal No. 3. Frederick Eng. Co., Frederick, Md., $28,750, Westinghouse Electric & Mfg. Co., 111 West Washington St., Chicago, $31,825, alternate $39,920, Sanford Reily Stoker Co., Chicago, $37,570, alternate $45,750 and $39,670, alternate $47,850.

Proposal No. 4. Dravo Co., 1292 30th St., $11,000, alternate $13,000, Superheater Co., Chicago, $12,000, Power Specialty Co., 111 West Monroe St. Chicago, $15,000.

Proposal No. 5. Green Fuel Economizer Co., 37 West Van Buren St., Chicago, (61) $58,200 (62) $49,040 (63) $45,360 (64) $45,980, alternate B. (61) $73,670 (62) $69,670 (63) $65,720 (64) $61,760, alternate C. (61) $64,040 (62) $60,440 (63) $56,870 (64) $53,300; B. F. Sturtevant Co., 530 South Clinton St., Chicago, $58,306, alternate A. $53,300, alternate B. $65,114, alternate C. $59,656.

Proposal No. 6 Bayley Mfg. Co., 732 Greenbush St., $31,934.

Wis., Oconomowoc — The city received bids for electric equipment for powerhouse from the General Electric Co., 53 West Jackson Blvd., Chicago, Ill., $14,130; Westinghouse Electric Co., 111 West Washington St., Chicago, Ill., $14,472.

Wis., Park Falls—The Flambeau Paper Co. is having plans prepared for a 2 and 4 story, 160 x 250 ft. pulp mill, etc. on Main St., here. About $250,000. G. Waldo, Mgr. G. F. Hardy, 309 Bway., New York City, Engr.

Wis., Ripon—C. D. Storck plans to build a 4 story, 50 x 140 ft. ice cream factory including power machinery, etc. About $75,000. Architect not yet selected.

Ia., Ottumwa—The Bd. Educ. will receive bids until May 3 for a 3 story, 192 x 275 ft. high school and a 1 story, 60 x 60 ft. power plant. About $700,000. J. A. Wagner, Secy. Croft & Boerner, 1106 Marquette Ave., Minneapolis, Minn., Archts.

Minn., Mankato—The Bd. Educ. voted $400,000 bonds to build a 3 story junior high school including a steam heating system. E. F. Searing, Clk. George Pass & Son, Archts. Rose & Harris, Auditorium Bldg., Minneaoplis, Engrs.

Minn., St. Paul — St. Joseph's Hospital, c/o Mother Grace Aurelia, 9th and Exchange Sts., will soon award the contract for a 6 story, 45 x 200 ft. hospital including a steam heating system on Exchange St. between St. Peter and Main Sts. About $350,000. J. H. Wheeler, 508 Exchange Bank Bldg., Archt.

Kan., Lawrence—The State Bd. of Administration, Topeka, is having plans prepared for a 2 story, 80 x 120 ft. power house here. About $100,000. R. S. Gamble, 1415 Fillmore St., Topeka, Archt.

Kan., Wichita—The Bd. Educ. will soon award the contract for a school and a 1 story, 77 x 94 ft. power house. About $350,000. L. J. Leland, Secy. L. Schmidt & Co., 121 North Market St., Archt. W. E. Willham Co, Interstate Bldg., Kansas City, Mo., Engr. Noted March 29.

Kan., Wichita—The Palace Theatre Co., 311 East Douglas Ave., is having plans prepared for a 3 story, 140 x 140 ft. theatre and office building including a steam heating system on Laurence Ave. About $700,000 Rapp & Rapp, 190 North State St., Chicago, Ill. Archts.

N. D., Mandan — The Benedictine Order, Richardton, is having plans prepared for an abbey and college buildings here. About $1,000,000. K. A. Loven, Bismarck, Archt.

Wyo., Shoshone—The United States Reclamation Service, Dept. of the Interior, Denver, Col., or Wash., D. C., will receive bids June 7 for furnishing riveted steel penstocks for the power plant here.

Mo., Columbia—The University of Missouri, plans to build a memorial building including a steam heating system. About $500,000. J. P. Jamieson, Security Bldg., St. Louis, Archt.

Mo., Medill—The Producers Storage Co. is in th market for complete machinery for its refrigerating plant.

Mo., St. Louis—The Excelsior Laundry Co., Grand and Bell Sts., is having preliminary plans prepared for a 2 story, 80 x 135 ft. laundry and a 100 x 140 ft. power plant on Grand and Washington Sts. About $200,000. S. W. Burley, Secy. L. Haeger, 3844 Utah Pl., Archt.

Ore., Salem—The State Bd. of Control will receive bids until May 15 for a water works system at the Institute for the Feeble-Minded, here. The project includes a deep well pump, pumphouse, etc. About $16,000. J. H. Kellar, Local Consult. Engr.

Cal., Los Angeles — Cutts Estate, c/o Morgan, Wells & Morgan, Archts., 1124 Van Nuys Bldg., will soon award the contract for a 6 story, 60 x 155 ft. store building on Spring St. near 7th St.

Cal., San Diego—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to build a radio station and 4 apartment dwelling here.

Cal., San Diego—The Carmelita Corp., U. S. Natl. Bank Bldg., is having plans prepared for a 10 story apartment house on Tras and Hickory Sts. About $2,500,000. Quale Bros., 601 Spreckler Bldg., Archts.

Ont., Bowmanville—C. Rehden & Son are preparing plans for a 1 story foundry including steam engines, boilers and electrical equipment, etc. About $60,000.

Ont., Georgetown — The city engaged Chipman & Power, Engrs., Mail Bldg., Toronto, to prepare plans and submit estimates to increase capacity of water works system by 500,000 gal. per day. A centrifugal pump will be installed. About $30,000.

Ont., Kingston — Queens University is having plans prepared for a 1 story thermodynamics building including a steam heating system, consisting of steam engines, compressors, etc. L. M. Arkley, Archt.

Ont., Ottawa—The Nukol Fuel Co., Ltd., 88 Bay St., Toronto, has purchased a site here and plans to build an artificial fuel plant on same. About $250,000. Mr. Heffernan, Jackson Bldg., Mgr.

Ont., Toronto—The Bd. Educ., 155 College St., will receive bids in May for a 3 story technical school including a steam heating and ventilating system consisting of motors, horizontal tubular boilers, etc. About $700,000. W. W. Pearse, Secy. and Treas.

Ont., Toronto — The Toronto Skating Club, c/o Lt.-Col. A. E. Kirkpatrick, 36 Toronto St., will receive bids in May for an artificial ice rink including a steam heating system on Duport St. Electric driven machinery will probably be installed in same. About $100,000. Langley & Howland, 112 King St., West, Archts. Noted Dec. 7.

Ont., Walkerville — The Utilities Bd. plans to build additions to the hydro-electric plant and is in the market for equipment. About $95,000. A. E. Cook, Secy.

CONTRACTS AWARDED

Mass., Danvers — The Dept. of Mental Deseases, State House, has awarded the contract for a boiler house at the State Hospital here, to the Rodge Boiler Wks., East Boston, at $16,800.

Mass., Dorchester—(Boston P. O.) The Schoolhouse Dept., City Hall, Boston, has awarded the contract for a 3 story, 171 x 177 ft. junior high school including a steam heating system on Maxwell and Selden Sts., to A. Piotti, 708 Dudley St., at $329,383.

N. Y., Lackawanna—The Parish Rectory, Ridge Rd. and South Park Ave., will build an 80 x 226 ft. Roman Catholic church on Ridge Rd. About $1,000,000. Work will be done by day labor.

N. Y., New York—(Bronx Boro) The Niewerhouse Bros., 316 East 161st St., New York City, will build a 10 story, 100 x 235 ft. hotel including a steam heating system on the Grand Concourse and 161st St. About $1,000,000. Work will be done by day labor.

N. Y., New York—(Brooklyn Boro) The Tillary Constr. Co., c/o Frank S. Parker, Archt. and Engr., 44 Court St., will build an 8 story, 100 x 200 ft. loft building including a steam heating system on Bridge and Duffield Sts. About $750,000. Work will be done by day labor.

N. J., Absecon — The City of Atlantic City, City Hall, Atlantic City, has awarded the contract for installing two superheaters at the pumping station here, to the Superheater and Eng. Co., 233 Bway., New York City, at $2,500; for jet ash conveyors, to James Merritt & Co., Front and Arch Sts., Philadelphia, Pa., $2,000. Noted April 12.

Pa., Williamsport — The Williamsport Hotel Co. has awarded the contract for a 9 story, 84 x 200 ft. hotel on 4th and William Sts., to W. M. Sutherland Bldg. & Contg. Co., Erie, Pa. About $800,000.

Md., Baltimore—The Western Baltimore & Annapolis R.R. has awarded the contract for a 3 story terminal and office building including a steam heating system, here, to George A. Fuller Co., 949 Bway, New York City. About $500,000.

W. Va., Fairmont — The Union Ind. School Dist. has awarded the contract for a 4 story high school including a steam heating ventilating, plumbing and wiring system, on Morgantown Ave., to John M. Kisner & Bros. Lumber Co. About $267,000.

Fla., Orlando — H. L. Beaman has awarded the contract for a 9 story hotel including a steam heating system, to Brogden, Ricketts & Haworth, Brown Bldg., Tampa. About $2,000,000.

Ky., Louisville—The Dixie Bell Refining Co., Inter-Southern Bldg., has awarded the contract for a refinery near the State Fair Ground. to the Roberts Constr. Co., Boston, Mass., at $500,000.

O., Cleveland — The Cleveland Electric Illuminating Co., Illuminating Bldg., has awarded the contract for a 1 story, 47 x 99 ft. substation at 3161 Cedar Rd., to Fred Hauselman, Illuminating Bldg. About $50,000.

O., Cleveland—The Wade Park Manor Co. has awarded the contract for a hotel on East 109th St. and Park Lane, to J. Giel & Sons, Citizens Bldg. About $2,500,000.

O., Cleveland Heights—(Warrensville P. O.) The Bd. Educ. has awarded the contract for installing a heating and ventilating system in the school on Noble Rd., to the Chappell Warren Co., 1836 St. Clair Ave., Cleveland, at $48,550. Noted March 22.

Mich., Detroit — The General Necessities Corp., 2436 Grand River Ave., will build a 2 story market building including a steam heating boiler and equipment. About $125,000. Work will be done by day labor.

Mich., Detroit—J. H. Kunsky, Madison Theatre Bldg., has awarded the contract for a 6 story, 155 x 250 ft. theatre and office building including a steam heating system on Broadway Ave., to the Longacre Constr. Co., 127 North Dearborn St. About $2,000,000.

Mich., Muskegon — The Lumberman's Natl. Bank has awarded the contract for an 8 story, 75 x 115 ft. bank and office building including a steam heating system, to Strom & Johnson, Grand Rapids. About $450,000.

Wis., Burlington—The city has awarded the contract for a centrifugal pump with motor, to the Stannard Power Equipment Co., 53 West Jackson Blvd., Chicago, Ill., at $4,120.

Wis., Oshkosh — The City Natl. Bank, c/o A. T. Hennig, Cashier, Main and High Sts., has awarded the contract for a 5 story, 58 x 105 ft. bank and office building on Main St., to the Flom Bros. Constr. Co., 52 State St. About $350,000. Contract for installing heating system will be sublet. Noted Feb. 8.

Wis., Sheboygan—The Bd. Educ., c/o C. U. Baley, City Hall, has awarded the contract for a 3 story, 60 x 250 ft. high school unit and power house on 9th and Jefferson Sts., to the L. M. Hansen Co., 113 West Walnut St., Green Bay, at $211,923.

Wis., Sheboygan — The East Wisconsin Electric Co., 8th and Pennsylvania Aves., has awarded the contract for an electric power line from Johnsonville to Ada, to A. Krotsch, Main St., Kiel. About $35,000.

Wis., Stevens Point — The Hardware Dealers Mutual Fire Insurance Co., Strongs Ave., has awarded the contract for installing a steam heating system in the proposed 3 story, 130 x 130 ft. office building, to J. B. Sullivan & Co., 210 Strongs Ave.

Wis., Two Rivers—The Wisconsin Textile Mfg. Co., c/o G. C. Hirst, Pres., has awarded the contract for a 1 story, 60 x 180 ft. factory, power house and dry kilns, to E. Stren, Main St. About $100,000. Noted April 19.

Ia., Ft. Madison — The Hinde Dauche Co., 401 West Water St., Sandusky, O., has awarded the contract for a paper mill to include a 2 story, 45 x 130 ft. rotary building, 4 story, 65 x 110 ft. heater building, 2 story, 40 x 300 ft., machine shop, 1 story, 120 x 220 ft. storage building and a 75 x 125 ft. power plant to H. K. Ferguson Co., Vickers Bldg., Cleveland, O. About $700,000.

Ia., Sioux City — The Bd. Educ., City Bldg., has awarded the contract for a 2 story, 120 x 230 ft. school including a steam heating system on 23d and Nebraska Sts., to Riesche & Sanborn, Leech and Floyd River Sts., at $211,910. Noted April 5.

Neb., Norfolk — The Bd. Educ. has awarded the contract for installing a steam heating system in the proposed high school, here, to The Orr Co., Sioux City, Ia. at $78,967. Noted Jan. 4.

Mo., St. Louis—The Society of St. Mary has awarded the contract for a 4 story, 72 x 175 ft. college and chapel including a steam heating system at Chaminade Station, to J. Grewe Constr. Co., Century Bldg. About $400,000.

Ark., Ft. Smith—The City Water Dept. has awarded the contract for furnishing two 300 hp. water tube boilers to Babcock & Wilcox Co., 85 Liberty St., New York City, $28,000; for two McCourtney centrifugal pumps to be driven by 2 Terrey steam turbine engines, capacity 8,000,000 gal. in 24 hours, to the Bessen Eng. Co., Kansas City, Mo., at $37,727; one Cockran water heater from the Thermal Efficiency Co., 1210 Scarritt Bldg., at $894.80; two boiler water feed pumps, Marsh pumps, to the Merkle Machinery Co., 508 Interstate Bldg., Kansas City, Mo., $875.

Idaho, Blackfoot—The city has awarded the contract for a small pumping station, elevated tank, tower, etc., here, to the Wheelwright Constr. Co., Main St., Ogden, Utah. Two deep well turbines of 750 g.p.m. direct connected to 100 hp. vertical motors will be installed in same. About $188,230.

Ont., Kitchner—The Dumarts Ltd., Breithaupt St., has awarded the contract for a 4 story, 50 x 140 ft. meat packing house including a steam heating system and refrigerating equipment on Guelph St., to the Mace Constr. Co., Toronto. About $100,000.

Ont., Waterloo—The Mutual Life Insurance Co. has awarded the contract for a 6 story office building addition including a steam heating system, to the Dickie Constr. Co., Ryrie Bldg., Toronto.

B. C., Prince Rupert — The Provincial Government, Victoria has awarded the contract for a 4 story court house, here, to Albert & McCaffrey, 514 Standard Bank Bldg., Vancouver. About $400,000.